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VALUE OF TREES TO RESIDENTIAL PROPERTY OWNERS WITH MOUNTAIN PINE BEETLE AND SPRUCE BUDWORM DAMAGE IN THE COLORADO FRONT RANGE

Richard G. Walsh, Ghebre Keleta, and John P. Olienyk

The work reported herein was funded, in part, by two U.S. Department of Agriculture, Forest Service projects entitled: "Pilot Study to Develop Guidelines for Determining the Effect on Residential Property Values of Tree Mortality from Mountain Pine Beetle and Spruce Budworm," USDA Forest Service Cooperative Agreement No. 16-950-CA, and "Assess Impacts of Mountain Pine Beetle Damage to Recreation Resource Supply and Demand in the Colorado Front Range," USDA Forest Service Contract Number 53-82X9-9-180.

Department of Economics
Colorado State University
Fort Collins, CO 80523

September, 1981

Final Report

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ABSTRACT

The purpose of this study was to develop and apply a procedure for measuring the effect of mountain pine beetle and spruce budworm damage on the value of trees to owners of residential property in the Front Range of the Colorado Rocky Mountains. A representative sample of 64 mountain homeowners were interviewed during the summer of 1980. Homeowners reported maximum willingness to pay for trees contingent on changes in several important forest quality variables including: number of trees six inches dbh or more on improved and unimproved mountain property, on adjacent property in the near view, size of trees, expectation of insect infestation, visible insect damage, distribution of trees, change in species, and presence of large specimen trees as illustrated by color photos. The value of trees was estimated on the basis of the contingent value approach as recommended by the U.S. Water Resources Council guidelines for studies of the value of changes in environmental quality. Ordinary least squares regression techniques and tests of significance were applied in analysis of the data. The results of the study will contribute to an assessment of forest insect control programs, and to citizen participation in management decisions and cost sharing programs.

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SUMMARY

The purpose of this study was to develop and apply a procedure for measuring the effect of forest quality on the value of trees to owners of residential property. In recent years, mountain pine beetle and spruce budworm infestations have affected forest quality on over 15 percent of the residential property in the Front Range of the Colorado Rocky Mountains, an area where private land has been increasingly converted from ranching to residential subdivisions. By 1980, there were an estimated 62,000 mountain homes and 112,000 unimproved lots in mountain subdivisions in the Front Range. From 1970-1980, the number of unimproved lots increased at a compound rate of 6-7 percent annually, compared to 4.8 percent for mountain homes, 2.8 percent for residential housing in the state as a whole, and 1.1 percent for the United States.

A representative sample of 64 mountain homeowners were interviewed at five study sites during the summer of 1980. Both seasonal and year around residents were sampled with 47 percent seasonal and 53 percent permanent residents. Characteristics of the sample were compared with the demographic estimates for the general population of Colorado. Generally, mountain homeowners have higher income and education than the population of the state. They tend to be older and more often employed as sales persons, professionals, and managers. Also, a larger proportion of mountain homeowners are retired.

The study sites represented the range of forest conditions in subdivisions in the Front Range, an area extending along the east side of the Rocky Mountains the length of Colorado from approximately 6,000 foot elevation to the continental divide with peaks over 14,000 feet. Ponderosa pine is common in stands averaging 160 trees six inches dbh or more per acre from 6,000 to 8,000 feet elevation with douglas fir occuring in moist north facing slopes at the higher end of the ponderosa pine range. Mountain pine beetle infestation turns ponderosa pine needles rust colored on dying trees. Spruce budworm infestation seldom kills douglas fir and white fir trees while discoloring of needles and defoliating stunts tree growth, causes top-kill, and die-back of branches.

Homeowners reported maximum willingness to pay for trees contingent on changes in several important forest quality variables including: number of trees six inches dbh or more on improved and unimproved mountain property, on adjacent property in the near view, size of trees, expectation of insect infestation, visible insect damage, change in species, distribution of trees, and presence of large specimen trees as depicted in color photos. The value of trees was estimated on the basis of the contingent value approach, as recommended by an

interagency committee of the U.S. government for studies of the value of changes in environmental quality. The method relies on the stated intentions of mountain homeowners to pay for trees with variations in forest quality depicted by color photos. The iterative bidding technique was adopted to assure that maximum points of indifference between having the amount of income stated or the attribute of forest quality were reported. Starting point was the value of improved and unimproved property without trees. Respondents answered "yes or no" to random increases in value of a one acre tract until the maximum amount the respondent was willing to pay was identified. Ordinary least squares regression techniques and tests of significance were applied in analysis of the data.

Mountain homeowners considered forest quality an important determinant of the value of mountain property which declined with distance. When tastes and preferences for trees were rated on a five-point scale of importance, 100 percent reported that trees were very important on their property, compared to 86 percent on adjacent property in the near view, and 83 percent in the far view. There was considerable variation in the opinion of mountain homeowners as to the relative importance of trees compared to other attributes of the quality of mountain property. Nearly one-half of the sample rated trees more important than rock outcroppings, compared to 42 percent more important than topography, 30 percent more important than view of the mountains, and 34 percent more important than nearness to streams and lakes.

Ordinary least squares statistical methods were used to estimate the relationship of tree values to number of trees six inches dbh or more on improved and unimproved mountain property. Number of observations of the relationship was 192 which proved sufficient for statistically significant analysis. The proportion of the variation in tree values explained by the independent variables in the equations was 0.26 and 0.28 as measured by R^2 adjusted for degrees of freedom. The overall equations were statistically significant at the 0.01 level as indicated by F values. All regression coefficients for the independent variables were significantly different from zero at the 0.01 to 0.10 levels. The usual tests of the assumptions of the regression model including multicollinearity and heteroscedasticity revealed little or no significant effects on the study results. Alternative forms of the contingent value equations were tried including linear, semi-log and double-log forms. However, the quadratic form which includes a linear and a squared term for trees provided the best fit of the relationship.

The functions were condensed to show the relationship between the two variables of interest. All independent variables other than number of trees and number of trees squared were multiplied by their means and added to the constant. The following reduced functions were obtained for the relationship between the number of trees per acre and value (in $100s) of trees on improved and unimproved mountain property:

$$\text{Willingness to Pay for Trees on Improved Property} = 51.7769 + 0.6595\text{TREES} - 0.0011\text{TREES}^2$$

$$\text{Willingness to Pay for Trees on Unimproved Property} = 43.2919 + 0.4474\text{TREES} - 0.0008\text{TREES}^2$$

The resulting functions provide a reasonable representation of the effect of trees on property values in the mid-range which is the relevant area of decision making. The functions should not be taken to the extreme of very low or very high number of trees. The total value functions were inverted U-shaped increasing at a decreasing rate to a maximum and then declining as the number of trees per acre increase. For example, the total value of trees on improved property increased from $5,826 per acre with 10 trees to $8,200 per acre this 50 trees, $10,673 per acre with 100 trees, $13,968 per acre with 200 trees, to a maximum of $15,063 per acre with 300 trees. Beyond this point, improved property values fell with additional trees. These tree values were added to the value of improved mountain property which averaged $88,891 without trees. A similar relationship was obtained for the contribution of trees to the value of unimproved property values with a base of $13,516 for one-acre tracts without trees. Trees contributed nearly $1,057 per acre more value to improved than to unimproved property with 10 trees per acre, $1,834 more value with 50 trees, $2,670 more with 100 trees, $3,891 more with 100 trees, and $4,479 more at maximum value.

Leisure time to engage in outdoor recreation contributed to knowledge of forest conditions and sensitivity to number of trees on mountain property. Retirement provided additional leisure time which contributed to knowledge of forest conditions and sensitivity to the number of trees on mountain property. Those who purchased and moved to Front Range mountain property in recent years were more sensitive to number of trees than those who have lived there for many years. Years of education was positively associated with value of trees. Also the market value of a homeowner's property contributed to the value of trees. The consumer surplus benefit from mountain home living contributed to willingness to pay for trees. Tastes and preferences for trees also were associated with sensitivity to the number of trees on Front Range mountain property. Other variables were controlled independent of the regression analysis. These included: location in the respondent's subdivision, lot size of one acre, gently sloping topography, access road in front, schools equally close, all utilities available, land value, and house value consistent with values reported in the study area.

The marginal value of trees on improved mountain property decreased from $64 per tree with 10 trees per acre to $55 per trees with 50 trees, $44 per tree with 100 trees, $33 per tree with 150 trees, $22 per tree with 200 trees, $11 per tree with 250 trees zero with 300 trees and negative with additional trees. This indicates that with sustained insect infestation, the adverse effect on tree values would rise at an increasing rate. Also, forest management programs which thin over-stocked stands of ponderosa pine and douglas fir have a favorable effect on tree values in the long run as number of trees per acre are reduced to optimum levels.

Tree values would decrease by 0.34 percent with a one percent decrease in number of trees six inches dbh or more on improved property, compared to 0.28 percent on unimproved property. The average elasticity of tree values with respect to number of trees was calculated in the range of 1-15 percent decrease from 240 trees per acre. This would be the effect on tree values of a general outbreak of forest insects which killed 1-15 percent of trees on mountain property. This compares to a study of tree values in the eastern United States in 1972 which reported that tree values would decrease by 0.13 percent with one

percent decrease in number of trees 6 inches dbh or more on improved property in Amherst, Mass. Apparently trees are more valuable in the arid western United States than in the east.

Tree values would decrease by 0.20 percent with each one percent decrease in the number of live trees six inches dbh or more on adjacent property in the near view. Average elasticity of tree values with respect to number of trees in the near view was calculated in the range of 1-15 percent decrease from 240 trees per acre on adjacent property. This would be the external effect of insect damage to trees in a visual corridor which may extend several hundred yards from improved mountain property depending on topography.

Tree values would decrease by 0.76 percent with each one percent increase in expectation of forest insect damage on improved property, compared to 0.61 percent on unimproved property. The average elasticity of tree values with respect to expectation of forest insect outbreak was calculated in the range of 1-50 percent of 212 trees per acre. This would be the effect on tree values of a general outbreak of forest insect infestation with forest entomologists predicting that 50 percent of the trees on mountain property will be killed within five years.

Tree values would decrease by 2.27 percent with visible discoloration of needles from insect infestation of one percent of the trees on improved property, compared to 1.80 percent on unimproved property. The average elasticity of tree values with respect to visible insect damage was calculated in the range of 1-15 percent of 212 trees per acre. This would be the effect on tree values during the second year after a mountain pine beetle attack when needles appear rust color on dead trees. It would be the annual effect of spruce budworm infestation of douglas fir.

Tree values would decrease by 0.29 percent with one percent increase in non-forested clearing as a result of forest insect infestation on improved property, compared to 0.40 percent on unimproved property. The average elasticity of tree values with respect to distribution of trees was calculated in the range of 1-50 percent concentration of trees on one-half of a one-acre tract. This would be the effect on tree values of insect infestation killing all of the trees on part of the property.

Tree values would increase by 0.02 percent with each one percent increase in the proportion of douglas fir to ponderosa pine on improved property, compared to 0.04 percent on unimproved property. The average elasticity of tree values with respect to species of trees was calculated in the range of 1-100 percent of 212 trees per acre. Mountain homeowners considered douglas fir slightly superior to ponderosa pine on the basis of forest insect infestation resistance.

Tree values would decrease by 3.64 percent with the loss of one percent of large specimen trees (two large trees per acre) to insect attack on improved property, compared to 2.61 percent on unimproved property. The average elasticity of tree values with respect to specimen trees 24 inches dbh or more was calculated in the range of 1-5 percent of 212 trees per acre, with all other variables unchanged. Mountain homeowners were sensitive to the aesthetic beauty

of large specimen trees and would suffer the most loss in value from their removal by forest insect infestation.

Tree values would decrease by 0.35 percent with each one percent decrease in the average size of live trees surviving forest insect infestation on improved property, compared to 0.32 percent on unimproved property. The average elasticity of tree values with respect to size was calculated in the range of 3-12 inches dbh, with all other variables unchanged. Statistical analysis of the effect of tree size on value showed that with reforestation after insect infestation, value would rise over the growth cycle of trees.

Full recovery of damages to Front Range forests would occur approximately 50 years after initial forest insect attack when it is estimated that regrowth of an insect damaged ponderosa pine forest would reach 7 inches dbh. Including the effect of regrowth of an insect damaged forest has a substantial effect on the calculation of annual values from the reported present values. It reduces the present value per dollar of annual value by 31-37 percent.

The results were applied to the problem of efficient insect control decision by mountain property owners. The optimum number of trees to protect per acre, on grounds of economic efficiency, would occur where marginal benefit per tree equals marginal cost of control. With marginal costs of forest management including insect control equaling about $3 per tree annually the optimum number of trees to protect on improved mountain property would be nearly 175 trees per acre. This would be equivalent to an insect control program which sprayed every two years at marginal cost of $6 per tree or a thinning program to encourage vigorous growth every five years at a marginal cost of approximately $15 per remaining tree. With the protection of 175 trees per acre, average annual owner benefits would equal $7.74 per tree. Thus, the annual benefit cost ratio of an owner's insect control program would equal 2.6.

The economic efficient level of expenditure on forest insect control by an association of homeowners and/or a public agency would be more than an individual owner. The average values reported by the sample of homeowners were expanded to the population of 62,000 improved properties and 112,000 unimproved properties in the Front Range in 1980. For example, with 15 percent fewer trees on improved mountain property, the present value of trees would decrease by an estimated $45.3 million, compared to $48.0 million on unimproved property. with 15 percent fewer trees on adjacent property in the near view, the present value of trees to owners of improved property would decrease by $27.7 million. This represent an external effect of insect infestation over which property owners have no control.

The results of this study will contribute to a Region II, U.S.D.A. Forest Service, Forest Insect and Disease Management Program. The information is an essential part of an assessment system designed to investigate the impacts of mountain pine beetle and spruce budworm infestation on forest resources in the Front Range of Colorado and in similar areas in the western United States. The assessment will include biological and psychological components as well as mountain property values.

In addition to the mountain property values reported here, the general public may value the preservation of forest quality on private land and be willing to pay for the option to view outstanding forest resources in the future, the knowledge that forest quality exists and is protected, and the satisfaction

from bequest of forest quality to future generations. Moreover, mountain property values were constrained by limited household income, availability of leisure time, and other variables. There may be psychological values associated with forest quality which exceed the economic measure of values reported here.

Also, there may be long-run ecological values of forest quality which are not included here. It is difficult for biologists to predict what these might be let alone measure and incorporate them into a mountain property value estimate. For this reason it seems that the present estimate of the effect of forest quality on mountain property values represents a conservative estimate of the total value to society of protecting forest quality. The inability of economic analysis to place a dollar value on unknown ecological effects should be recognized in making decisions about forest insect control programs.

VALUE OF TREES TO RESIDENTIAL PROPERTY OWNERS WITH MOUNTAIN PINE BEETLE AND SPRUCE BUDWORM DAMAGE IN THE COLORADO FRONT RANGE

Richard G. Walsh, Ghebre Keleta, and John P. Olienyk*

A major outbreak of mountain pine beetles, Dendroctonus ponderosae Hopkins, occurred in 1965 and continues to the present on two million acres of mixed age ponderosa pine, Pinus ponderosa var. scopulorum Engelm., in the Front Range of the Rocky Mountains, Colorado. Overall loss of trees in the area extending 180 miles from the Wyoming border south to Canon City, Colorado, was estimated as 15 percent of approximately 150-170 trees per acre six inches dbh or more. Loss of trees in the Roosevelt National Forest located in the northern Front Range was reported as 25 percent with less damage in the Arapahoe, Pike, and Isabel National Forests in the southern Front Range [McCambridge, Hawksworth, Edminster, and Laut, 1981]. The insects attack and kill progressively larger trees with the rate of kill function rising from 1-9 inches dbh and constant from 10-14 inches dbh or more, although some large trees survive. A study of Lory State Park located in the northern Front Range reported 25 percent of the trees were lost and 44 percent of the merchantable board foot value equal to 984 board feet per acre valued at $14. Thus, with an average 15 percent loss of trees on two million acres of ponderosa pine in the Front Range, the merchantable timber loss would equal approximately 1,180 million board feet valued at $16.8 million.

A major outbreak of western spruce budworm, Choristoneura occidentalis Freeman, occurred in 1974 and continues to the present time on 1.52 million acres of mixed age douglas fir, Pseudotsuga menziesii var. glauca (Beissn.) Franco, on

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*Dr. Walsh is Professor, Dr. Olienyk is Assistant Professor, and Mr. Keleta was formerly Graduate Research Assistant in the Department of Economics, Colorado State University, Fort Collins, Colorado.

moist north facing slopes of the Front Range of Colorado. Spruce budworm also have attacked white fir in the Southern Front Range. Few trees have been killed by spruce budworm thus far, however, discoloration and devoliation of newly grown needles has been highly visible. Several consecutive years of defoliation stunts tree growth, causes top-kill, and die-back of branches. If the infestation continues for approximately 10 years, it will eventually kill host trees.

In addition to the loss of merchantable timber, forest insect management decisions require knowledge of the economic value of trees in the residential areas of the forest where the value of trees for shade and aesthetic quality exceeds their value for conversion into wood products [Averill, Gunter, Lister, and Sonnen, 1977]. When mountain pine beetles or spruce budworms attack host trees, the discoloration of needles caused by the insect infestation detracts from the aesthetic beauty of the forest in the short run. As dead trees are removed or decay, the long run effect is to reduce the density of the stand of live trees and thus change the quality of the forest. While the unsightliness resulting from mountain pine beetle and spruce budworm infestation is very obvious, even to the most casual observer, the long run effect is more subtle. Once the dead trees decay or are removed, it is likely that most purchasers of land in mountain subdivisions would be unaware than an insect attack ever occurred in the area. The fact remains, however, that the value of the forest on property where insect damage has occurred may be significantly different from what it would have been in the absence of the insect damage. Thus, owners may be willing to pay more for improved and unimproved property in a mountain subdivision without damage than after an insect attack. The demand for mountain property as residential homesites and thus its market value may decrease.

The purpose of this study was to develop and apply a procedure for measuring the effect of mountain pine beetle and spruce budworm damage on the value of trees to owners of improved and unimproved mountain property in the Front Range of Colorado. Specific objectives were:

(1) define the nature of private land inholdings in the National Forests affected by insect infestation;

(2) determine the trends in the development of subdivisions in forests;

(3) identify the attractiveness of mountain property affected by insect infestation;

(4) empirically analyze the effects of insect infestation on the contribution of trees to the value of improved and unimproved mountain property;

(5) project the future impact on the contribution of trees to mountain property values without insect infestation suppression programs.

The procedure adopted was to interview a representative sample of 64 owners of mountain property in Front Range forests during the summer of 1980. Homeowners reported maximum willingness to pay for improved and unimproved mountain property contingent on changes in forest quality variables including: number of trees six inches dbh or more on the property and on adjacent land in the near view; size of trees, expectations of insect damage, visible insect damage, change in species, presence of large specimen trees, and distribution of trees. Tree values were estimated on the basis of the contingent value approach, as recommended by the U.S. Water Resources Council [1979] for studies of the economic value of changes in environmental quality. Ordinary least squares regression techniques and tests of significance were applied in analysis of the data.

The results of this study will contribute to a Region II, USDA Forest Service, Forest Insect and Disease Management program. The information is an essential part of an assessment system designed to investigate the impacts of mountain pine beetle and spruce budworm infestation on forest resources in the Front Range of Colorado and in similar areas in the western United States. This assessment will include biological, recreational, economic, and psychological components. The overall assessment system will be used to measure: (1) the benefits of alternative infestation control programs, (2) the costs of alternative programs to reduce or remove infestation, (3) the costs of monitoring and enforcement of alternative regulations, and (4) where chronic unemployment exists, the indirect or secondary benefits and costs of alternative programs. The information will be used to help formulate and evaluate alternative actions by public and private land managers to lessen the impact of insect damage to forest resources.

A review of previous research revealed several related studies. One study produced acceptable results for the eastern U.S. of dollar loss in residential property from tree mortality caused by the gypsy moth [Payne, White, McCay and McNichols, 1973]. Trees contributed an average of 7 percent to the value of $25,000 to $50,000 homes on lots averaging 20,000 square feet (about one-half acre) in Amherst, Massachusetts. The statistical relationship of property value contributed by trees (V) to number of trees 6 inches dbh and larger (t) had the following form:

$$V = \$300\ t - \$5.22\ t^2$$

$$N = 212 \qquad R^2 = .78$$

The value added by trees increased at a decreasing rate to a maximum value of $4,310 with 29 trees and then declined. The study included no properties with

more than 50 six-inch dbh and larger trees on lots of 20,000 square feet. A tree value of $1,950 was assigned to lots with 50 or more trees.

The 1972 study found that color photos in sets of 3-5 provided a meaningful way to study tree values. The market value of 212 residential properties was estimated by a panel of nine real estate appraisers. The appraiser values were within one percent of the values assigned by a sample of 200 homeowners, each evaluating 10-15 photos. Values from tax assessor records were not reliable measures of market value. The appraiser survey showed that tree values were significantly related to the value of the house, size of house, size of lot, and neighborhood. Thus, these factors should be controlled in future studies. Number of trees below 6 inches dbh was not an important determinant of value, nor was the percent of land covered by tree crowns.

In a subsequent study, Payne and Strom [1975] asked a panel of real estate appraisers to value unimproved land based on black and white photos of seven architectural model sites in which all variables were held constant except number of trees and tree configuration. They found that a model of a 12-acre tract of open land zoned for development in Amherst, Massachusetts, was valued at an average of $1,490 per acre when no trees were present, $1,860 when 33 percent forested, $2,050 when 66 percent forested, and $1,830 when 100 percent forested. The 12-acre tract included 14 housing lots, 840 linear feet of road and two areas of common land, each occupying two-thirds of an acre. Size of trees, number of trees, and size of lot were not reported. Model trees represented mixed northern hardwoods. The only land value determinants allowed to vary were the amount and distribution of tree cover. Scattered arrangements of trees were valued more highly than concentrated arrangements. Topography of the site was

nearly flat. They concluded that there may be significant interaction of tree values with topography, size of tract, and other variables.

Morales, Boyce and Favaretti [1975] analyzed 14 variables which explained the sales price of 60 residential properties in Manchester, Connecticut, with and without mature trees. They concluded that mature trees added 6-9 percent to the sales price of residential properties, with other variables constant. Purcell [1956] compared the sales price of residential property zones in Toronto, Canada, with and without trees, and concluded that trees contributed an average of $300 per tree. Paige [1964] estimated that 20,000 street trees in Beverly Hills, California, contributed an average of $900 per tree to property values. Love [1977] interviewed 22 property owners in the Front Range of Colorado to compare the value of tracts with and without trees in the same mountain subdivision. He concluded that ponderosa pine trees added 10-60 percent to the value of unimproved mountain lots.

The remainder of this report is organized into 16 sections. We outline the concept of the effect of forest quality on the value of trees to owners of mountain property in Section 2. The following three sections describe the measure of value, the study area, subdivision development trends, and the method of research. Section 6 reports the psychological importance of trees to mountain property owners, and the relative importance of trees compared to other attributes of environmental quality. Sections 7 and 8 present the empirical findings of this study with respect to the market value of trees on the property and on adjacent land in the near view. Section 9 presents the effect of tree size on value. This is followed by five sections on the effects of other aspects of forest quality including expectation of insect damage, visible insect damage, large specimen trees, change in species, and distribution of trees on mountain property. Section 15

contains a projection of the recovery of damages as future regrowth occurs in an insect damaged forest. This is followed by a section which brings in study results together with applications to insect control decisions. Section 17 contains the main conclusions of this report and a discussion of the limitations of economic analysis when applied to problems of forest quality. The appendix contains the sources of literature and a copy of the questionnaire.

CONCEPTS OF ECONOMIC VALUE

For many goods and services, of which mountain home living is one, value of the experience is affected by attributes of resource quality. Lancaster [1966] developed a consumer decision model in which individuals demand goods and services to satisfy a desire for a basic set of attributes associated with them. For example, forest quality is viewed as one of a number of attributes of residential property in the Front Range of the Colorado Rocky Mountains. The level of forest quality affects the quality of shade and aesthetic services and, therefore, individual satisfaction and benefits from mountain home living. In addition to forest quality, the value of mountain property is determined by other attributes of a site such as location, access, view, nearness to streams and lakes, rock outcroppings, topography, etc.

Insect infestation detracts from the aesthetic beauty of the forest in the short run and as the dead trees are removed, the long run effect is to reduce the number of trees. Both short- and long-run effects reduce individual satisfaction from the experience of mountain home living; hence, the demand for mountain property as residential sites and the value of the sites may change.

The concept of the value of forest quality is firmly based in the economics of consumer demand as applied by Freeman [1979] and others [Brigham, 1965; Correll, Lillydahl and Singell, 1978]. Demand is the relationship between price and the quantity of a good or service which consumers are willing and able to purchase. In this particular case, demand for residential mountain property is defined as the relationship between the quantity of improved and unimproved mountain property and the maximum amount buyers are willing and able to pay rather than do without. Such a demand curve can be interpreted as a marginal

willingness to pay curve, relating marginal value to quantity of mountain property developed. This relationship is graphically illustrated as line AB in Figure 1 showing the demand for improved mountain property, holding all other relevant social economic variables constant including forest quality. Line DC represents a shift in the demand curve for improved mountain property in the presence of forest insect infestation.

The value of forest quality is measured by the difference in the area under the demand curves with and without insect infestation. When forest quality on residential property changes, the area between the two curves, ABCD would be the loss of utility measured in dollars resulting from the change. Alternatively stated, ABCD represents the most an individual would be willing to pay for forest insect infestation control programs.

When the price of improved mountain property is known, as indicated by line P in Figure 1, the consumer surplus value of trees can be predicted. With an insect damaged forest, the net value or consumer surplus of mountain home living is area HGD. Now assume that an insect infestation control program restored forest quality. In economic terms, the effect is a shift in the demand curve for improved mountain property back to line AB. The net economic benefit of improved forest quality is the increase in consumer surplus, defined as the area between the two demand curves above price, area DGEA.

The benefits from insect infestation control programs can be divided into two categories. The first is the increase in utility consumer surplus to those $0\text{-}Q_1$ property owners of Front Range forest affected by insect infestation. This is the area DGFA. This area represents their increase in willingness to pay to maintain present use of mountain property. In addition, with forest quality maintained, the greater attractiveness of the Front Range relative to

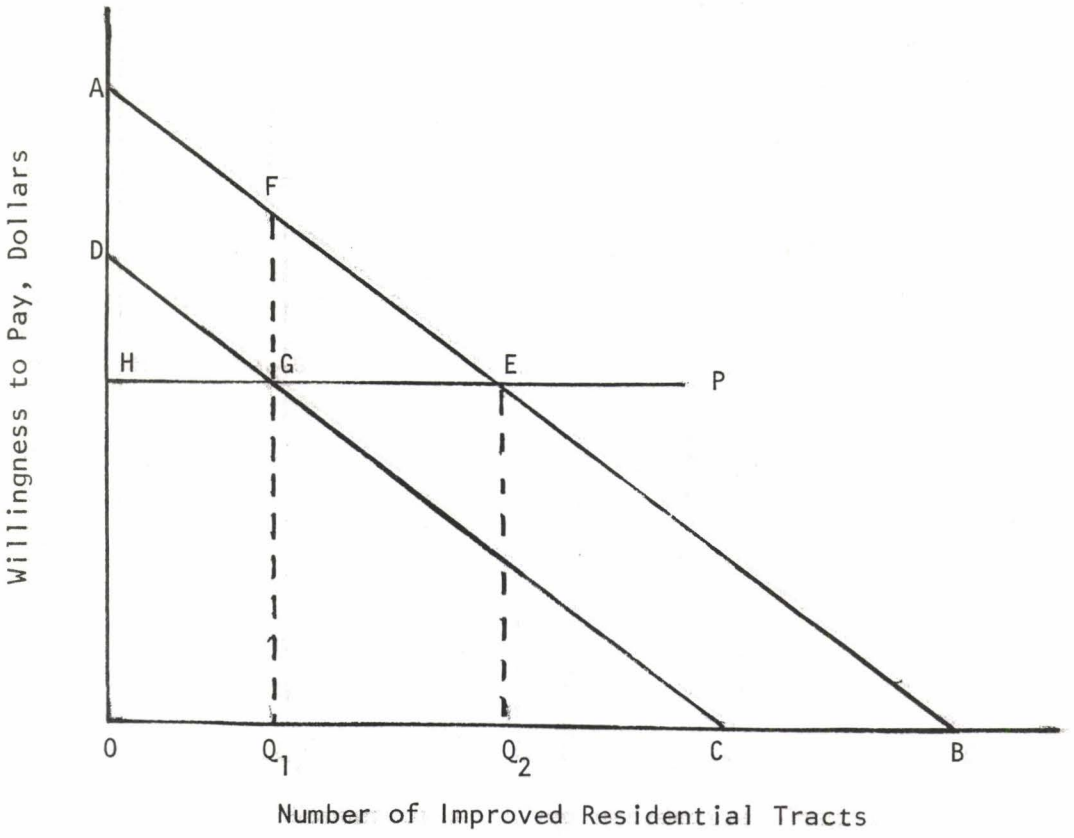


Figure 1. Demand Curves for Improved Mountain Property With and Without Forest Insect Damage.

alternative residential areas results in an increase in demand for improved residential tracts to Q_1-Q_2. There is a benefit associated with this increase in demand for improved residential tracts which is equal to the area GEF. Thus, Figure 1 shows forest quality will be associated with both changes in willingness to pay and changes in the demand for mountain home living.

In addition to the effect of forest quality on residential mountain property. there are external effects of insect infestations on neighboring property. These public goods aspects of the problem contribute to both benefits and costs of residential mountain property ownership. The value of mountain property is enhanced by quality of the forest on adjacent land in the near view. Moreover, some benefits of forest quality on mountain property accrue to the general public through aesthetic enjoyment of the view from mountain roads and trails. The costs of forest insect control on mountain property may be increased by failure of neighboring property owners to control forest insects. Costs rise with reinfestation from neighboring trees.

CONTINGENT VALUE APPROACH

The direct interview method used in this study was recently recommended by the U.S. Water Resources Council [1979] as providing acceptable measures of the economic value of environmental change. The inter-agency committee established procedures for application of a contingent value approach based on the stated intentions of resource users. In this study, mountain homeowners were asked to report the maximum amount of money they would be willing to pay for trees on improved and unimproved mountain property contingent on hypothetical changes in forest quality.

An iterative bidding technique recommended by the Council was adopted in this study to encourage homeowners to report maximum willingness to pay, representing the point of indifference between having the amount of income stated or the attribute of forest quality. Starting point was the value of improved and unimproved property without trees. Respondents answered "yes" or "no" to random increases or decreases in value of a one acre tract until the maximum amount the respondent was willing to pay was identified.

The procedure was repeated for each of three levels of: forest density on the property, on adjacent land in the near view, and tree size. Respondents were shown color photos depicting three levels of forest density. These included: a low number of trees per acre, a medium number, and a high number. The three levels of tree size were 3 inches, 6 inches, and 12 inches dbh. Then respondents were asked to report how their high value of trees would change if conditions changed in the following ways: (1) forest entomologists report that one-half of the trees on the lot would be killed by insect infestation within five years; (2) fifteen percent of the trees on the lot would have reddish needles because

of insect damage; (3) predominant species of trees on the property would change from ponderosa pine to douglas fir; (4) arrangement of trees would change from a scattered pattern to a concentrated grouping on one half of the lot.

Homeowners were asked to assume that all other conditions would remain unchanged except for the attributes of forest quality. It was assumed that the improved and unimproved property valued was located in the subdivisions where respondents live. Access was by public road in front of the property. All schools were equally close. Available utilities included electricity, sewer and water were in front of the lot. Size of lot was held constant at one acre, roughly 200 by 200 feet. Topography was specified as gently sloping land with little or no rolls. Ponderosa pine trees were in a scattered arrangement. The house was valued at $80,000 and included 1,500 to 2,000 square feet of living space, two baths, two-car garage, fireplace, three bedrooms, and a family room. Lot values ranged from $10,000-$20,000 consistent with the average value of $13,500 reported in the subdivisions.

A combination of factors contributed to the realism of the simulated market situation. Property value represents an established routine method of paying for trees as one important attribute of mountain property. It was logical to expect that changes in forest quality would affect their willingness to pay for mountain property. Quality of forest resources has affected the value of residential property in the past. Thus, it was reasonable for respondents to assume that the only way to assure a given level of forest quality was by payment of the stated amount. This method of payment introduces the exclusion principle in that forest quality can be appropriated by individuals in the value of mountain property owned. There exists a market in which individuals can purchase a desired level of forest quality and exclude other individuals from trespassing on their property. However, the scenic quality of trees on private land also

has public good aspects; if it is protected by one individual homeowner, it is equally available to others to view from the distance of a nearby road or adjacent property.

No homeowner in the sample rejected property values as an appropriate method of payment for trees. It was clearly the best available common denominator to compare the relative values of the sample of mountain homeowners interviewed. This relatively neutral measure of value was selected over alternatives such as annual tax, insect control association dues, or commercial insect control and management fees to avoid emotional reaction and protect against the method of valuing trees. A question was prepared to ask respondents who may report they were not willing to pay anything for forest quality: is it because they receive no benefit from trees, limited income constrains their ability to pay, or they believe it is unfair to expect property owners to pay for forest quality which should be provided by public agencies? No respondent in the sample reported a zero value of forest quality, so this question was not used.

Tests of the possibility of strategic bias were performed as suggested in the case of contingent valuation studies [U.S. Water Resources Council, 1979]. There is a possibility that homeowners may engage in strategic behavior, overstating their willingness to pay for trees in order to gain government subsidized insect control programs, or understating willingness to pay in order to avoid higher assessments by insect control districts which operate in the state. If homeowners as a group biased their willingness to pay responses, a frequency distribution would show clustering of values at abnormally high or low levels. The distribution of tree values reported did not indicate abnormal behavior, which suggests that there was little or no strategic bias of the study results.

Clawson and Knetsch [1966] have proposed enhanced private land values as one measure of the benefit of public resource management. The contingent value approach was first applied by Davis in a 1963 study of the consumer surplus benefit of recreation activities in the Maine woods. He asked recreationists to report the maximum additional cost they would pay before deciding to discontinue the activities at the study site. The procedure has been successfully applied to value recreation resources in the Main woods [Knetsch and Davis, 1966], a water basin in British Columbia [Meyer, 1974], water quality in Colorado [Walsh, Greenley, Young, McKean, and Prato, 1978], fishing in Washington State [Mathews and Brown, 1970]; the Western Flyway [Hammack and Brown, 1974], wildlife in the Southeastern region [Horvath, 1974], air quality in New Mexico [Randall, Ives, and Eastman, 1974] and at the Glen Canyon National Recreation Area [Brookshire, Ives, Schultze, 1976].

Many economists have reservations about the accuracy of values obtained from contingent value questions [Freeman, 1979]. For example, Samuelson [1954] warned that ". . . it is in the selfish interest of each person to give false signals, to pretend to have less interest . . ." in forest quality when he suspects that he may actually have to pay the amount he reveals as his willingness to pay. In this case, respondents were asked to reveal their willingness to pay in what is clearly a hypothetical situation. Respondents knew that the study was sponsored by the University for scientific purposes, thus, they could infer that responses would have no direct effect on their payment obligation.

It is notable that objections to the contingent value approach have been primarily theoretical, as empirical evidence of systematic bias is at best inconclusive. Davis, who pioneered the method in a study of the recreation

benefits of the Maine woods, concluded that the reported values were not significantly different from those obtained by the market-related travel cost approach [Davis, 1963; Knetsch and Davis, 1966]. Randall and associates developed refinements in the contingent valuation technique and presented a persuasive case for its effectiveness in the valuation of environmental quality. They studied the benefits from improved air quality and other environmental amenities in the Four Corners area of New Mexico [Randall, Ives and Eastman, 1974] and the Glen Canyon National Recreation Area [Brookshire, Ives and Schultze, 1976]. They found no measurable strategic behavior by environmentalists compared to other respondents. Replication of the studies resulted in similar values. Bohm [1972] conducted a controlled experiment comparing five alternative measures of willingness to pay for a public good, including actual payment in cash of the stated willingness to pay. He found no significant difference in values reported by five groups, each presented with an alternative willingness to pay format. Bohm [1979] concluded that the theoretical objections to the contingent valuation approach could be resolved by application of an interval method. Two benefit functions would be derived, based on minimum and maximum incentives to misrepresent willingness to pay. The midpoint of the interval would represent the most acceptable value.

The willingness to pay measure of the value of forest quality was selected over the alternative, willingness to sell or accept compensation for reduced forest quality. A number of studies including Bishop and Heberlein [1979] have found that willingness to sell values including actual cash sales are considerably higher than willingness to pay, whether the latter is measured by the contingent value or the travel cost approach. This is the expected result, as willingness

to pay would be constrained by limited household income and time budgets as well as other variables [Gordon and Knetsch, 1979]. More realistic estimates of tree values are expected under these constraints. The acceptance of compensation would increase the respondent's level of income and result in value estimates which are unrestrained by the utility of dollars normally earned as income.

The contingent value approach is gaining broad acceptance. It is generally recognized that the method requires careful wording of questions and well-defined market situations with which the respondent is familiar. In several of the studies cited above more than one approach was used. No one method has emerged superior in all cases, and there is need for further research to tests the effectiveness of alternative willingness to pay formats.

STUDY AREA

The study area was the Front Range of the Rocky Mountains of Colorado shown as the shaded area on the map of the state presented as Figure 2. Specific study sites included Red Feather-Crystal Lakes, identified as area "A" on the map; Estes Park, area "C"; Nederland, area "D"; Woodland Park, area "E"; and Lake Isabel, area "F".

Red Feather Lakes is a small unincorporated community located 120 miles northwest of Denver at an elevation of 8,200 feet, and constitutes a pocket of private property in Roosevelt National Forest. Estes Park is a community of 3,000 people located 70 miles northwest of Denver at an elevation of 7,500 feet. The Roosevelt National Forest borders the Estes Park area on the north, east, and south with Rocky Mountain National Park on the west. Nederland is a small community of about 700 people located 45 miles northwest of Denver at an elevation of 8,200 feet, encircled by Roosevelt National Forest. Woodland Park is a community of 1,500 people located 15 miles northwest of Colorado Springs and 70 miles southwest of Denver at an elevation of 8,465 feet in the Pike National Forest. Lake Isabel is located in a mountain valley 150 miles southwest of Denver at an elevation of 8,000 feet in San Isabel National Forest.

These sites were selected as representative of subdivisions in the Front Range. All sites had ponderosa pine forest with evidence of damage from mountain pine beetle infestation and douglas fir forest with evidence of spruce budworm damage. Both seasonal and year around residents were sampled with 47 percent seasonal and 53 percent permanent residents. Each site was defined to encompass a radius of approximately 10 miles to sample a range of forest quality conditions.

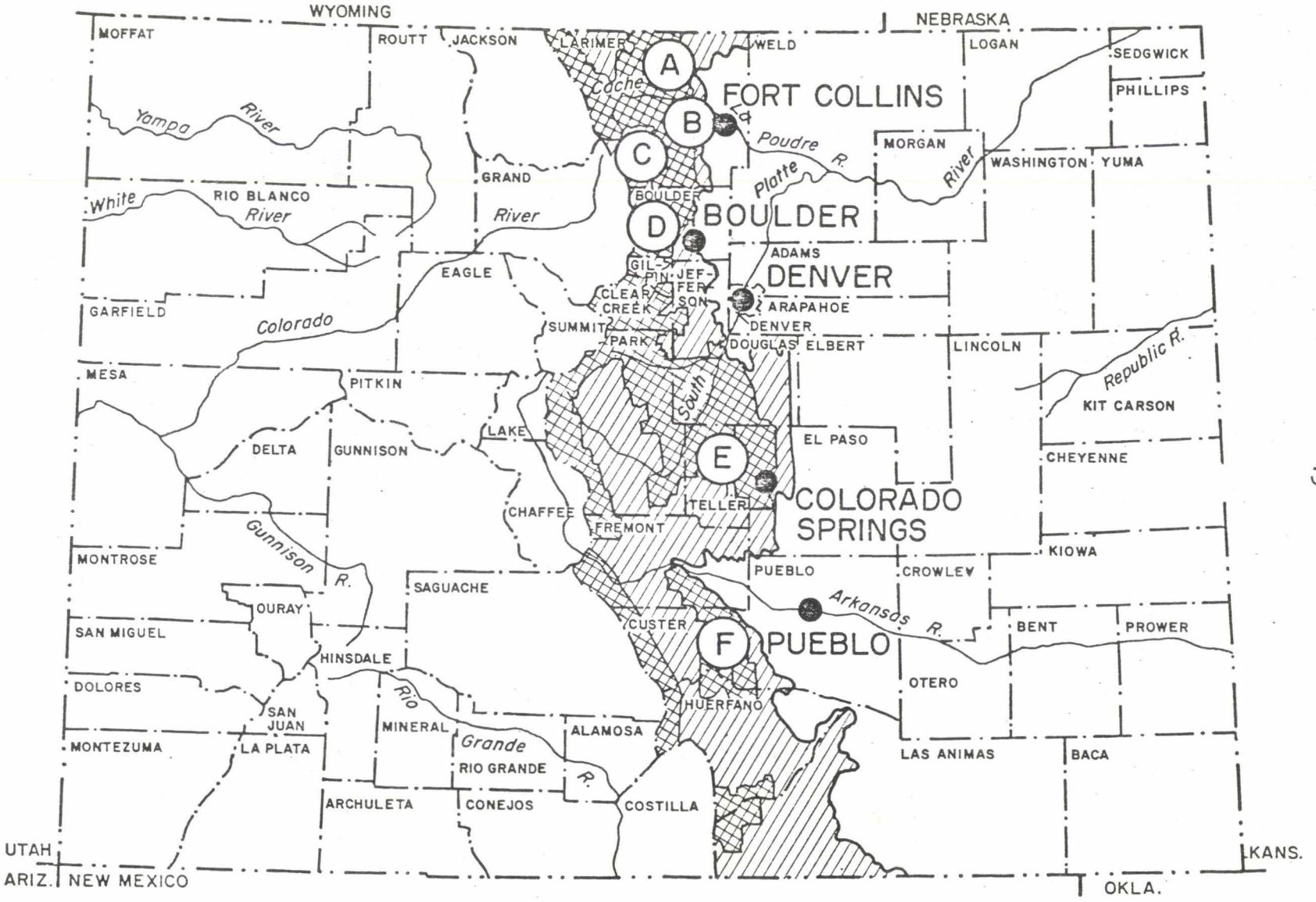


Figure 2. The Front Range Study Areas, Rocky Mountains, Colorado, 1980.

The Front Range extends along the east side of the Rocky Mountains the length of Colorado and is bordered on the north by Wyoming and on the south by New Mexico. The eastern boundary of the Front Range is approximately the 6,000 foot elevation contour. The western boundary is the western Larimer county line, which divides the North and South Platte River Basins, from the Wyoming border to the Continental Divide which extends through Rocky Mountain National Park to approximately the center of the state where the boundary becomes the western Park and Fremont county lines. To the south, the western boundary is the crest-line of the Sangre de Cristo mountain range.

The Front Range constitutes an area of approximately 8.5 million acres equal to 12.8 percent of the 66 million acres in the state. Public land in National Forests total 3.2 million acres, equal to 37.6 percent of the total Front Range. Included are the 2.2 million acres contained in the Pike and San Isabel National Forests in southcentral Colorado, part of the Arapahoe National Forest located on the Front Range, and Roosevelt National Forest in northcentral Colorado with nearly 1 million acres. National Forests on the Front Range equal 23.7 percent of the 13.5 million acres of National Forests in the state.

Second growth forest interspersed with meadows of shrubs, grasses, and wildflowers occurs throughout the Front Range from the Wyoming border south to New Mexico. Ponderosa pine is common in stands averaging 160 trees per acre from 6,000 to 8,000 feet elevation in a semi-circle down the Front Range of the Rocky Mountains, across the southern end of the state, and a third of the way up the west side. Douglas fir occurs on moist north-facing slopes at the higher end of the ponderosa pine range. Lodgepole pine occurs from 8,000 to 10,500 feet in central and northern Colorado. Englemann spruce and subalpine fir forests are located at 9,000 to 11,500 feet in scattered

stands. Aspen occur anywhere from 8,000 to 10,000 feet. Bristlecone and limber pine are found near timberline at 11,500 feet. Above timberline, the growing season is short and forests disappear. Small grasses, shrubs, and broad-leaved plants are characteristic of the arctic tundra. Much of the area consists of bare rock and the open lackscape provides vistas of many miles.

Colorado has more mountains than any other state in the Continental U.S. and nearly half of them are on the Front Range. The state is dominated by the high peaks of the southern Rocky Mountains. There are 831 peaks between 11,000 and 14,000 feet elevation and 53 peaks over 14,000 feet. The Continental Divide passes through the midsection of the state with massive peaks, long ridges, and deep valleys carved by vast sheets of moving ice some 10,000 years ago. The mountains are criss-crossed by deep canyons carrying streams both east and west. The headwaters of the Arkansas and South Platte Rivers originate at the higher elevations of the Front Range. Many lakes occupy depressions left by receding glaciers. Streams originate from alpine lakes with pristine water quality and gradually yield to degradation as elevation diminishes and human encroachment increases. Most of the existing and potential wilderness areas in the state occur at elevations of 9,000 feet to over 14,000 feet and consist principally of ice and rock, with thin soil supporting forest below timberline of 11,500 feet.

The Front Range is cool and dry with summer temperatures seldom rising above 90 degrees Fahrenheit which is comfortable when accompanied by low humidity. Snow and rainfall yield 15 to 30 inches of water annually. Many wildlife species are present including bald and golden eagles, bighorn sheep, black bear, mule deer, elk, moose, beaver, marten, and other small mammals, birds and fish (brook, brown, cutthroat, and rainbow trout).

The Front Range of the Rocky Mountains in Colorado has been subject to increasing subdivision into residential tracts. Table 1 shows that the

Table 1. Estimated Number of Mountain Homes, Front Range of Colorado, 1970 and 1980.

County	Front Range Area		Number of Mountain Homes[a]		Homes Per Square Mile		Proportion of Seasonal Recreation Homes, 1980	
	Proportion of County	Square Miles	1970	1980	1970	1980	Number	Percent
Larimer[b]	80%	2,091	3,800	5,000	1.8	2.4	1,200	24.0
Boulder	65%	488	3,527	4,973	7.2	10.2	1,213	24.4
Gilpin	100%	149	1,164	2,060	7.8	13.8	94	4.6
Clear Creek	100%	394	2,505	2,756	6.4	7.0	301	10.9
Park	100%	2,166	2,217	6,230	1.0	2.9	348	5.6
Jefferson	85%	667	8,403	13,613	12.6	20.4	1,628	11.9
Douglas	85%	717	3,585	7,170	5.0	10.0	860	12.0
Teller	100%	554	2,190	5,782	4.0	10.4	1,006	17.4
El Paso	25%	540	4,551	5,780	8.4	10.7	786	13.6
Fremont	85%	1,328	1,594	1,992	1.2	1.5	235	18.0
Custer	100%	737	891	1,096	1.2	1.5	199	18.2
Pueblo	10%	240	1,361	1,402	5.7	5.8	206	14.7
Huerfano	85%	1,341	1,609	2,012	1.2	1.5	301	15.0
Las Animas	40%	1,918	2,141	2,398	1.1	1.3	10	0.4
TOTAL		13,334	39,538	62,264	3.0	4.7	8,387	13.5

a. These estimates are based on number of residential units reported by the 1970 U.S. Census [U.S. Department of Commerce, 1973] updated to 1980 on the basis of change in population from 1970 to 1980. Number of residential units in the Front Range for Larimer, Douglas, Fremont, and Huerfano Counties were estimated on the basis of residential units per square mile in neighboring mountain counties. Number of seasonal recreation homes in these counties was estimated on the same basis. Seasonally vacant housing units were reported by the U.S. Census for other counties.

b. Includes the Estes Park incorporated area with an estimated 746 housing units in 1970 and 1,254 in 1980; the Front Range excluding the eastern two and one-half ranges with 3,000 housing units in 1970 and 3,450 in 1980; and the eastern two and one-half ranges with an estimated 54 housing units in 1970 and 296 in 1980.

number of mountain homes on the Front Range increased from less than 40,000 in 1970 to over 62,000 in 1980 or by 60 percent. By 1980, the number of mountain homes in Park County was nearly three times 1970 levels, two and one-half times in Teller County, and nearly doubled in Gilpin, Jefferson, and Douglas Counties. With 2.6 persons per household, the population of the Front Range was estimated as 100,000 in 1970 and 162,000 in 1980. To put this in perspective, it was equivalent to 7.5 persons per square mile in 1970 and 12.2 persons in 1980.

The increase in population living on the Front Range during the past decade has been nearly twice the 30 percent increase in Colorado's population, and nearly 5.3 times the 11.4 percent increase in population of the United States. Population growth on the Front Range was equivalent to a compound rate of 4.8 percent per year compared to 2.8 percent for the state as a whole, and 1.1 percent for the United States.

Seasonal recreation home population on the Front Range in 1980 was estimated as nearly 22,000 persons and permanent residents 140,000 persons. There were an estimated 8,400 seasonal recreation homes on the Front Range in 1980, equal to 13.5 percent of total mountain homes. The proportion of seasonal recreation homes to total homes ranged from less than one percent in Las Animas County in southern Colorado to more than 24 percent in Boulder County near Denver.

Table 2 shows that the total number of lots, both improved and unimproved, in mountain subdivisions on the Front Range increased from 97,000 in 1970 to 174,000 in 1980 or about 80 percent. Unimproved means that the lots have been plotted and a subdivision has been filed but mountain homes have not been constructed. In 1970, the total number of subdivided lots was nearly 2.5 times the number of improved lots on which a mountain home had been constructed. By

Table 2. Estimated Number of Subdivided Lots in Mountain Subdivisions on the Front Range of Colorado, 1970 and 1980.

County	Lots in Mountain Subdivisions			
	Number of Lots[a/]		Total Acres[b/]	
	1970	1980	1970	1980
Larimer	9,350	14,000	20,159	30,184
Boulder	8,676	13,924	18,705	30,020
Gilpin	2,863	5,768	6,173	12,436
Clear Creek	6,162	7,177	13,285	15,474
Park	5,454	17,444	11,759	37,609
Jefferson	20,671	38,116	44,567	82,178
Douglas	8,819	20,076	19,014	43,284
Teller	5,387	16,190	11,614	34,906
El Paso	11,195	16,184	2,576	34,893
Fremont	3,921	5,578	8,454	12,026
Custer	2,192	3,069	4,726	6,617
Pueblo	3,348	3,926	7,218	8,464
Huerfano	3,958	5,634	8,533	12,147
Las Animas	5,267	6,714	11,356	14,475
TOTAL	97,263	174,339	209,699	375,875

a. The Census of Housing does not include subdivided lots and their number has not been tabulated for all counties on the Front Range. The number of lots in mountain subdivisions were estimated on the basis of a study underway of rural subdivisions in Larimer County [Waples, 1981]. The number of lots in mountain subdivisions on the Front Range of Larimer County was reported as 8,850 in 1970 and approximately 13,000 in 1980, excluding the eastern two and one-half ranges and the Estes Park incorporated area. It was assumed that Estes Park and the eastern two and one-half ranges contained 500 unimproved lots in 1970 and 1,000 in 1980. The ratio of unimproved to improved lots was estimated as 2.46 in 1970 and 2.80 in 1980. It was assumed that there are at least as many subdivided lots relative to improved lots in other Front Range counties as in Larimer County.

b. With 2.156 acres per lot as reported for a sample of 64 improved mountain homesites on the Front Range in 1980.

1980, the number of subdivided lots was 2.8 times the number of improved lots on the Front Range of Colorado. To put this in perspective, at the build-out rate of 2,272 mountain homes per year from 1970 to 1980, the available supply of subdivided lots constituted a 50 year supply.

The 80 percent increase in supply of building sites on the Front Range during the past decade was nearly one-third greater than the 60 percent increase in demand for mountain homes. It was 2.7 times the 30 percent increase in demand for residential units in the state of Colorado, and seven times the 11.4 percent increase in demand for housing units in the United States. Growth in subdivided lots in mountain subdivisions on the Front Range was equivalent to a compound rate of 6-7 percent per year.

Total land use by mountain subdivision in 1980 was 378,000 acres equal to 590 square miles. This was equivalent to 4.4 percent of the 12,334 square miles on the Front Range of Colorado. In 1980, the 62,000 mountain homes occupied an estimated 134,000 acres or 1.6 percent of the land on the Front Range. In the same year the 112,000 unimproved lots in mountain subdivisions contained a total of nearly 242,000 acres or 2.8 percent of the land area on the Front Range. These estimates are based on an average of 2.156 acres of land per lot in mountain subdivisions as reported for a sample of 64 improved mountain homesites on the Front Range in 1980.

SURVEY DESIGN

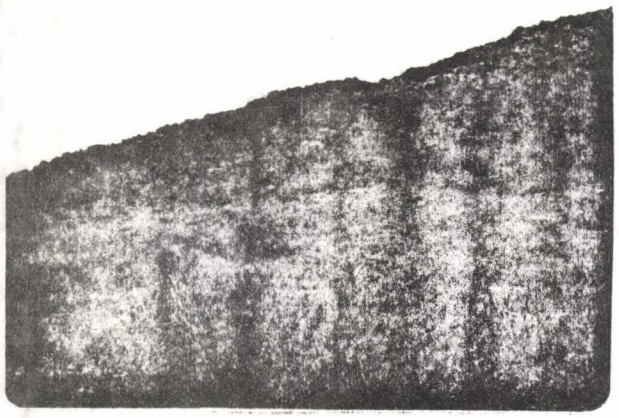
The basic economic data for this study were obtained from interviews with a representative sample of 64 mountain property owners in their homes during the summer of 1980. The stratified random sample was selected to represent the geographic distribution of existing subdivisions in the Front Range. Thirty-five homeowners were interviewed in the northern Front Range at Red Feather-Crystal Lakes, Estes Park, and Nederland; and 29 homeowners were interviewed in the southern Front Range at Woodland Park and near San Isabel Lake. These study sites were defined to encompass a radius of approximately 10 miles to include a range of forest quality conditions. Both seasonal and year around residents were sampled with 47 percent seasonal and 53 percent permanent residents.

Interviews were taken on random days throughout the summer. Interviewing was initiated at the beginning of the day at a randomly selected residence in the subdivision. Subsequent interviews were conducted at randomly selected residences throughout the day. The procedure was designed to assure that all mountain homeowners in the study sites have an equal chance of selection. The four trained interviewers were graduates of the University program in natural resource economics with previous experience interviewing recreation users of Front Range forest resources.

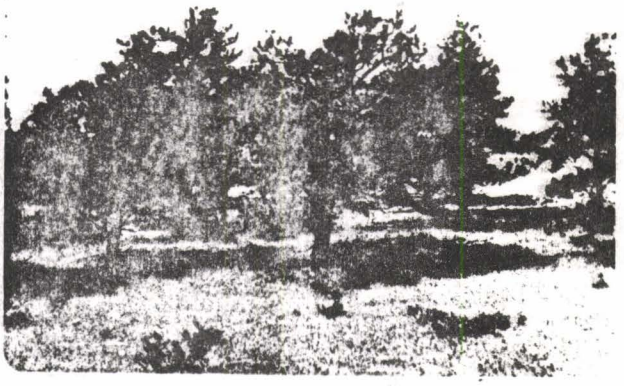
A questionnaire was prepared to obtain information on the value of trees to owners of mountain property. While the questionnaire was long with 96 questions, it was designed and pretested for clarity and ease of answering. The questionnaire was designed to allow interviews to be completed in 30 minutes in order to minimize inconvenience, and to avoid respondent fatigue and lapse of concentration. See the appendix to this report for a copy of the questionnaire.

Sample size was determined by standard statistical practice to obtain results within the 90 percent level of statistical significance. For example, each of the 64 respondents provided three observations of the contribution of trees to the value of mountain property contingent on changes in number of trees. Respondents were shown color photos depicting six levels including: zero, 20-40, 60-80, 100-120, 140-160, or 200-300 trees per acre. They reported values for each of three levels of tree density per acre within this range. Thus, a total of 192 observations were available for the variable of primary interest, which was sufficient for significant statistical analysis.

Figure 3 shows black-and-white reproductions of six pictures of ponderosa pine forest with 0-300 trees per acre six inches dbh or more. Identical color pictures were shown each homeowner interviewed along with color pictures of visible mountain pine beetle damage, dead and down trees with slash on the ground, and large specimen trees. They were selected from an inventory of over 100 exposures taken of ponderosa pine forest in the Front Range of Colorado. The photos represent a reasonable visual depiction of the range of forest quality in the study area, with a minimum of variation in other attributes of environmental quality such as rock outcroppings, ground cover, and sky. Homeowners were asked to assume that the photos were identical except for variation in forest quality. Interviewers identified the number of trees per acre in the photos and the average distance between trees. For example, the second picture was identified to some respondents as having 40 trees per acre averaging 30 feet apart. The second picture was identified to some respondents as having 100 trees per acre 20 feet apart. The sixth picture was identified to some respondents as having 300 trees per acre 10 feet apart. This use of color photos conforms with recommendations of an interagency committee of the U.S. government [U.S.



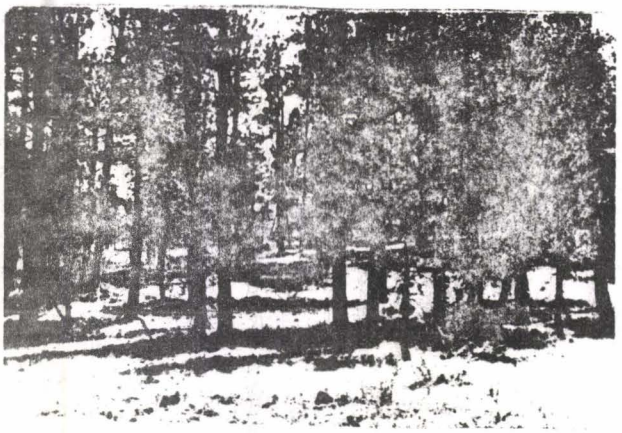
No Trees



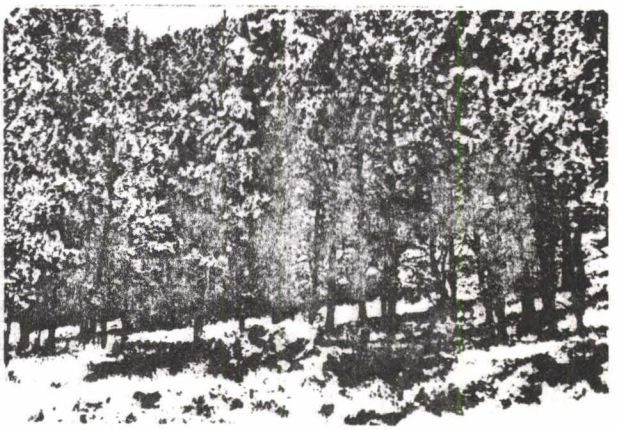
20 to 40 Trees per Acre

60 to 80 Trees per Acre

100 to 120 Trees per Acre



140 to 160 Trees per Acre



200 to 300 Trees per Acre

Figure 3. Six Levels of Forest Quality, Front Range of the Rocky Mountains, Colorado, 1980.

Water Resources Council, 1979] for studies of the economic value of changes in environmental quality.

Table 3 shows a comparison of the characteristics of the sample with the demographic estimates for the general population of Colorado. Generally, mountain homeowners have higher income and education than the population of the state. They tend to be older and are more often employed as sales persons, professionals, and managers. Also, a larger proportion of mountain homeowners are retired.

The average annual income of households in the sample at $36,800 was 60 percent higher than the estimated average income of $23,000 for all households in the state. The proportion of sample households with low income under $10,000 per year was 4.7 percent compared to 17.8 percent of general population. Sample households with high income of $25,000 and over was 54.8 percent compared to 32.1 percent of the general population.

The average age of the head of households included in the sample at 47.6 years was somewhat higher than for the general adult population reported as 42.6 years in the 1970 Census. The sample under-represented young adults 18-30 years of age. It was less likely that young adults would have accumulated sufficient capital to purchase mountain real estate. The sample over-represented the middle-aged 30-44 and 45-64 years of age. Persons 65 years of age and older were also over-represented, although to a lesser extent than for the middle-aged.

Average household size of the sample at 3.3 persons was slightly higher than statewide. The 1970 Census reported an average of 3.1 persons per occupied housing unit in the state. Family size may have declined in the past decade as a result of the declining birth rate, increase in number of housing units occupied by a single person, and increase in the number of wives who work outside the home.

Table 3. Comparison of State Population and Homeowners Sample Demographic Profile Estimates, Colorado, 1980.

Statistic	Sample	Population[a]
Male/Female Ratio	73.4/26.6	50.6/49.4
Family Size	3.3	3.1
Average Age	47.6	42.6
Age Distribution		
18-29	9.4	31.1
30-44	37.5	27.3
45-64	35.9	28.4
65 and over	17.2	13.2
Average Education	15.1	13.0
Average Income	$36,800	$23,000
Income Distribution		
Under $10,000	4.7	17.8
$10,000-$14,999	12.5	16.8
$15,000-$24,999	25.0	33.3
$25,000 and over	54.8	32.1
Occupation		
Housewife	19.8	17.6
Student	0.9	7.0
Retired	25.0	8.9
Farm	0	2.0
Non-skilled Labor	2.6	8.0
Skilled Labor	6.0	6.3
Sales	9.5	3.9
Clerical	0.9	9.5
Manager	13.8	4.8
Professional	12.0	7.2
Teacher, Other Government	8.6	16.7
Other	0.9	9.1

a. Average age 18 years and over, age distribution, household size, median education 25 years and over, and occupations from the 1970 Census [U.S. Department of Commerce, 1974]. Occupations were listed for 1,632,126 adults in the State of Colorado. Income distribution is for 1977-78 from tabulations by the Colorado Division of Revenue, and average income is for families with one or more wage earner in 1978 and updated to 1980.

Occupations of the adult members of sample households were similar to the distribution of occupations of the adult population of the state in 1970. The proportion of skilled laborers and housewives were virtually identical. Somewhat over-represented were sales persons, professionals, managers, and retired persons. Under-represented occupations included college students, clerical workers, unskilled laborers, farmers, teacher, and other government employees.

Average education of the sample at 15.1 years of age was over two years higher than for the adult population of the state, estimated as 13.0 years. The 1980 Census is expected to show that average education levels have increased resulting from in-migration of persons with some college.

Over two-thirds of the respondents were men, although they represent approximately one-half of the general population of the state. In large part, this resulted from the fact that the head of a household is considered the spokesman for most families, albeit after consultation with other family members. Thus, it is reasonable to conclude that most of the information obtained applies to the household as a unit.

IMPORTANCE OF TREES

Table 4 shows the importance of trees to mountain homeowners. The sample of homeowners rated the importance of trees on mountain property, on adjacent property, and in the far view. Tastes and preferences for trees were rated on a five-point scale with: (1) extremely important, (2) very important, (3) moderately important, (4) somewhat important, and (5) not important. Average scores and standard deviations are shown for each of the three items.

There was some difference of opinion among mountain homeowners as to the relative importance of trees. However, 100 percent considered trees an important determinant of the value of mountain property. Importance declined with distance. One hundred percent considered trees very important on their property, compared to 86 percent on adjacent property, and 83 percent in the far view.

Table 5 shows the importance of trees to homeowners relative to other attributes of the quality of mountain property. Mountain homeowners rated the importance of trees relative to rock outcroppings, topography, view of the mountains, and nearness to streams and lakes. The relative importance of trees compared to each of these attributes of resource quality was rated on a five-point scale, with: (1) much more important, (2) more important, (3) same importance, (4) less important, and (5) much less important. Average scores are shown along with standard deviation.

There was considerable variation in the opinion of mountain homeowners as to the relative importance of trees. The largest group of respondents, 42-50 percent, rated trees equally important to rock outcroppings, topography, view

Table 4. Importance of Trees to Mountain Homeowners, Front Range, Colorado, 1980.

Location of Trees	Importance of Trees, Percent Reporting					Average Score	Standard Deviation
	Extremely Important (1)	Very Important (2)	Moderately Important (3)	Somewhat Important (4)	Not Important (5)		
Importance of Trees on the Property	64.1	35.9	0.0	0.0	0.0	1.36	0.48
Importance of Trees on Adjoining Property	35.9	50.0	14.1	0.0	0.0	1.78	0.68
Importance of Trees in the Far View	39.1	43.8	14.1	3.1	0.0	1.81	0.79

Table 5. Importance of Trees Relative to Other Aspects of Landscape Quality, Mountain Homeowners, Front Range Colorado, 1980.

Other Aspects of Landscape Quality	Percent of Sample Reporting Trees as					Average Score	Standard Deviation
	Much More Important (1)	More Important (2)	Same Importance (3)	Less Important (4)	Much Less Important (5)		
Importance of Trees Relative to Rock Outcroppings	18.8	37.5	43.8	0.0	0.0	2.25	0.76
Importance of Trees Relative to Nearness to Streams and Lakes	6.3	28.1	46.9	17.2	1.6	2.80	0.86
Importance of Trees Relative to Topography	6.3	35.9	50.0	7.8	0.0	2.59	0.73
Importance of Trees Relative to Rocky Mountain View	1.6	35.9	42.2	20.3	0.0	2.81	0.77

of the mountains, and proximity to stream and lakes. The table shows that 56.3 percent rated trees more important than rock outcroppings, compared to 42.2 percent more important than topography, 37.5 percent more important than view of the mountains, and 34.4 percent more important than nearness to streams and lakes. The table shows that 20.3 percent rated trees less important than view of the mountains, and 18.8 percent less important than nearness to streams and lakes.

NUMBER OF TREES ON PROPERTY

Figures 4-5 and Table 6 show the effect of number of live trees six inches dbh or more on the value of improved and unimproved mountain property. It was estimated that the value of trees per acre would decrease by $\underline{=}0.34$ percent with a one percent decrease in number of trees on improved property, compared to -0.28 percent on unimproved property. These average or arc elasticities of tree values with respect to number of trees on mountain property were calculated in the range of 1-15 percent decrease from 212 trees per acre, all other variables unchanged. This represents the effect of mountain pine beetle infestation which reduces the number of trees on residential mountain property. The following section of this report will present results with respect to the number of trees on adjoining property.

Ordinary least squares statistical methods were used to estimate the relationship of property value to number of trees and other social economic variables. The dependent variable was the contribution of trees to the value of mountain property. The sample of 64 homeowners reported their maximum willingness to pay for improved and unimproved mountain property contingent on changes in the number of trees six inches dbh or more on site. Number of trees was illustrated by four color photos of low, medium and high trees per acre. This resulted in a total of 192 observations of the relationship between value and number of trees, which was sufficient for statistically significant analysis. The proportion of the variation in the value of trees explained by the independent variables included in the equations was .26 and .28 as measured by R^2 adjusted for degrees of freedom. All regression coefficients were significantly different from zero at the 0.00 to 0.10 level. The overall equations were statistically significant at the

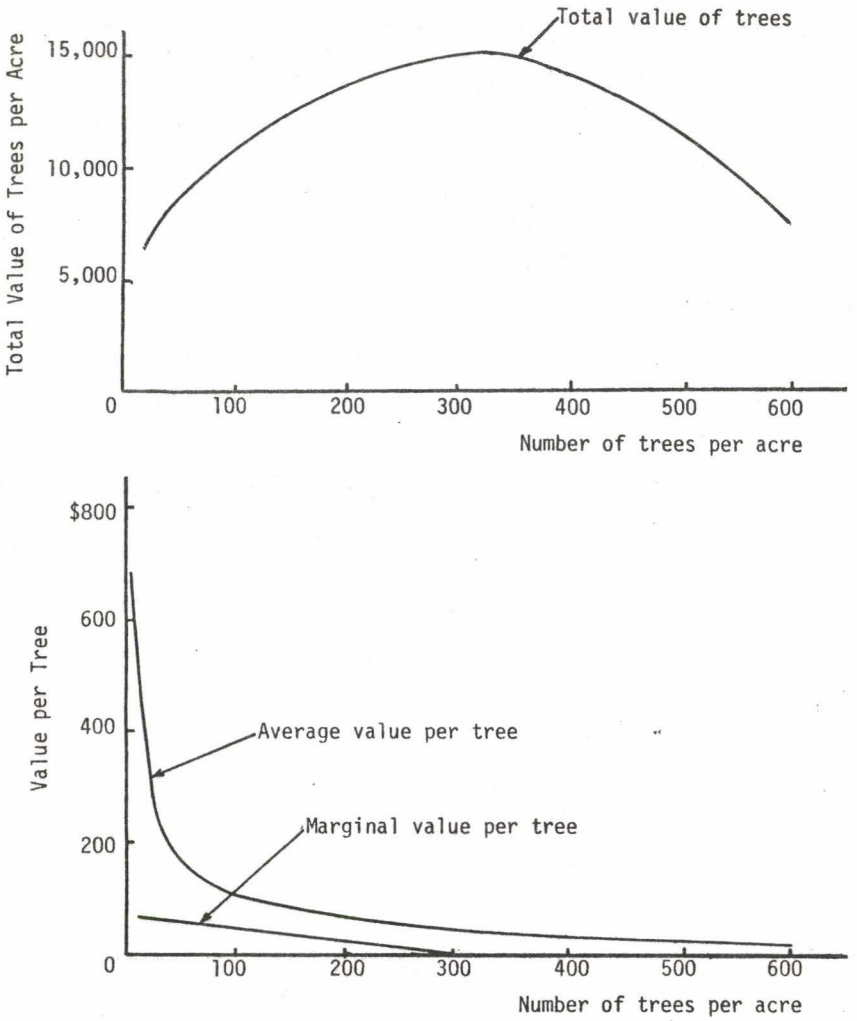


Figure 4. Total, Average, and Marginal Value of Trees Six Inches dbh or More on Developed One Acre Tracts, as Reported by Mountain Homeowners in Front Range Forests, Colorado, 1980.

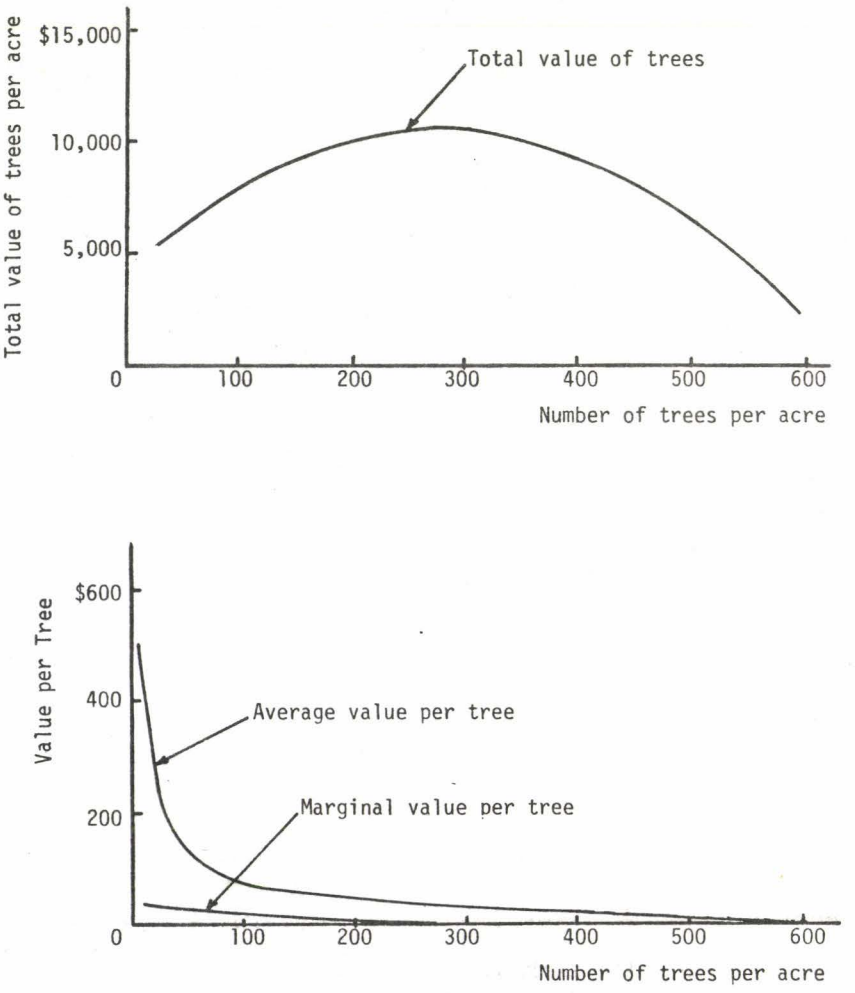


Figure 5. Total, Average, and Marginal Value of Trees Six Inches dbh or More on Undeveloped One Acre Tracts, as Reported by Mountain Homeowners in Front Range Forests, Colorado, 1980.

Table 6. Total, Average and Marginal Value of Trees Six Inches dbh or More on Improved and Unimproved One-Acre Tracts, Mountain Homeowners, Front Range, Colorado, 1980.

Number of Trees Per Acre	Improved			Unimproved		
	Total Value	Average Value	Marginal Value	Total Value	Average Value	Marginal Value
10	$ 5,826	$582.60	$63.75	$ 4,769	$476.86	$43.14
25	6,758	270.31	60.45	5,398	215.91	40.74
50	8,200	164.00	54.95	6,366	127.32	36.74
75	9,505	126.74	49.45	7,235	96.46	32.74
100	10,673	106.73	43.95	8,003	80.03	28.74
125	11,703	93.62	38.45	8,672	69.37	24.74
150	12,595	83.97	32.95	9,240	61.60	20.74
175	13,350	76.99	27.45	9,709	55.48	16.74
200	13,968	69.84	21.95	10,077	50.39	12.74
225	14,448	64.21	16.45	10,346	45.98	8.74
250	14,790	59.16	10.95	10,514	42.06	4.74
275	14,995	54.53	5.45	10,583	38.48	0.74
300	15,063	50.21	-0.05	10,551	35.17	-3.26
325	14,993	46.13	-5.55	10,419	32.06	-7.26
350	14,785	42.24	-11.05	10,188	29.19	-11.26
375	14,440	38.51	-16.55	9,857	26.28	-15.26
400	13,958	34.89	-22.05	9,425	23.56	-19.26
425	13,338			8,894		
450	12,580			8,262		
475	11,685			7,531		
500	10,653			6,699		
525	9,483			5,768		
550	8,175			4,736		
575	6,730			3,605		
600	5,148			2,373		

0.01 level as indicated by an F value of 43.35 to 51.30. Alternative forms of the equation were tried including linear, quadratic and logarithmic forms, with the quadratic model providing the best fit of the relationship of interest. The usual tests of the assumptions of the regression model including multicolinearity and heterscedasticity revealed no significant effects on the study results.

The stepwise regression technique was used to estimate the coefficients for each model. The general equations were condensed to show the relationship between the two variables of interest. All independent variables other than number of trees and number of trees squared were multiplied by their means and summed to form a constant. The following reduced functions were obtained for the relationship between the number of trees per acre and value (in $100s) of trees on improved and unimproved mountain property:

$$\text{Willingness to pay for trees on improved property} = 51.7769 + 0.6595\text{TREES} - 0.0011\text{TREES}^2$$

$$\text{Willingness to pay for trees on unimproved property} = 43.2919 + 0.4474\text{TREES} - 0.0008\text{TREES}^2$$

As expected, these equations indicate that trees contribute more value to improved property than to unimproved. With otherwise identical conditions, improved property values increased by approximately $66 per additional tree and declined by $0.11 per additional tree squared; while unimproved property values increased by $45 per additional tree and declined by $0.08 per additional tree squared. The resulting functions provide a reasonable representation of the effect of trees on values in the mid-range which is the relevant area of decision making. The functions should not be taken to the extreme of very low or

high numbers of trees. The latter represents an extrapulation as few observations were taken beyond 350 trees per acre.

Figures 4-5 and Table 6 show that the resulting total value functions were inverted U-shaped. The total value of trees on improved property increased at a decreasing rate from $5,826 per acre with 10 trees to $8,200 per acre with 50 trees, $10,673 per acre with 100 trees, $13,968 per acre with 200 trees, to a maximum of $15,063 per acre with 300 trees. Beyond this point, improved property values fell with additional trees per acre. By comparison, the total value of trees on unimproved property increased at a decreasing rate from $4,769 per acre with 10 trees to $6,366 per acre with 50 trees, $8,003 per acre with 100 trees, $10,077 per acre with 200 trees, to a maximum of $10,584 per acre with 280 trees. Thereafter, unimproved property values fell with added trees per acre. These tree values were added to the base value of unimproved mountain property which averaged $13,516 per acre and improved property which averaged $88,891 for a one-acre tract without trees. Thus, trees contribute nearly $923 per acre more value to improved than to unimproved mountain property with 10 trees per acre, $1,780 more value with 50 trees per acre, $3,814 more with 100 trees, $4,137 more with 200 trees, and $4,933 more at maximum values. The average number of ponderosa pine trees in cut-over Front Range forests was reported to be 160 trees six inches dbh per acre, however, this varies from zero to several hundred.

The marginal value of additional trees on improved property decreased at nearly a constant rate from $64 per tree with 10 trees per acre to $55 per tree with 50 trees, $44 per tree with 100 trees, $33 per tree with 150 trees, $22 per tree with 200 trees, $11 per tree with 250 trees and zero with 300 trees. The marginal value of additional trees on unimproved property decreased from $43 per

tree with 10 trees per acre to $37 per tree with 50 trees, $29 with 100 trees, $21 per tree with 150 trees, $13 per tree with 200 trees, $5 per tree with 250 trees, and zero with 280 trees.

Other social economic variables shift the vertical intercept of the function relating value of trees on improved and unimproved property to number of trees per acre. Table shows the variables which were significantly related to willingness to pay for trees. Those which were positively associated with the value of trees include: annual days of outdoor recreation, market value of property, consumer surplus benefit of mountain home living, years of education, employment as a worker, retired, and preference variables--importance of trees relative to rock outcroppings, trees on adjoining property and trees in the far view. Variables which were negatively associated with the value of trees include: total willingness to pay to live in mountain home, years lived in the study area, years of mountain property ownership, number of bedrooms, worth more than cost to live in mountain home, and membership in an environmental organization. Other variables which were tried and found not significantly associated with the value of trees include: average household income, total monthly housing cost, family size, age, sex, years lived in mountain home, size of property, calendar year mountain home built, housewife, government employee, professional or manager, member of sportsman's organization, and importance of trees relative to topography, rocky mountain view, and nearness to stream and lakes.

Other important variables were controlled independent of the regression analysis. The willingness to pay questions assumed that the mountain property shown in the color pictures were exactly the same except for the number of trees. The size of lot was held constant at one acre, roughly 200 x 200 feet. Ponderosa pine trees were in a scattered arrangement. Topography was specified as

Table 7. Ordinary Least-Square Equation Estimates of the Value of Trees Six Inches dbh or More on Improved and Unimproved One Acre Tracts, Mountain Homeowners, Front Range, Colorado, 1980.

Independent Variables	Regression Coefficients[a]	
	Improved	Unimproved
Number of Trees on One Acre Tract	0.6595 (3.66)	0.4474 (2.99)
Number of Trees on One Acre Tract Square	-0.0011 (-1.95)	-0.0008 (-1.75)
Annual Days of Outdoor Recreation	0.2798 (4.08)	0.0912 (-1.70)
Retired; 1=yes, 0=no		40.8891 (3.50)
Current Market Value of Property, thousands	0.8302 (4.35)	
Total Willingness to Pay to Live in Mountain Home	-0.0711 (-5.33)	
Surplus Value of Mountain Home Living	0.2693 (4.06)	
Years Lived in Study Area	-1.0007 (-1.56)	
Importance of Trees on Adjoining Property, 5-point scale	-19.9601 (-2.92)	-22.6416 (-3.09)
Worth More than Cost to Live in Mountain Home; 1=yes, 2=no	36.4273 (2.88)	
Importance of Trees Relative to Rock Outcroppings, 5-point scale		-25.4599 (-4.44)
Worker; 1=yes, 0=no		27.4225 (2.22)
Years of Education		3.1353 (2.67)
Years of Mountain Property Ownership		-1.1704 (-1.81)
Number of Bedrooms in Mountain Home		-10.1677 (-1.81)
Member of Environmental Organization; 1=yes, 2=no		66.1967 (5.72)
Importance of Trees in Far View, 5-point scale		-10.1537 (-1.72)
Adjusted R^2	.26	.28
F Significance	60.57	43.35
Number of Observations	192	192

a. Number in parentheses below each coefficient represents student t-ratios for the null hypothesis. All variables are significant at the .00 to .10 level of confidence.

gently sloping land with little or no rolls. Access was by public road in front of the property. All schools were equally close and lots were in the same subdivision in the study areas in Front Range forests. Utilities included electricity, sewer and water were available in front of the lot. The house was valued at $80,000 and included 1,500 to 2,000 feet of living space, two baths, two-car garage, fireplace, three bedrooms, and a family room. Lot value averaged $10,000-$20,000 consistent with values without trees reported in the study area.

Leisure time to engage in outdoor recreation contributed to knowledge of forest conditions and sensitivity to the number of trees on mountain property. As expected, the value of trees on improved property increased by nearly $28 with each additional day of outdoor recreation per year, compared to $9 for unimproved property. Retirement provided additional leisure time which contributed to knowledge of forest conditions and sensitivity to the number of trees on mountain property. Retired persons valued trees on unimproved property by nearly $4,089 per acre more than other mountain homeowners.

The market value of homeowner's property contributed to sensitivity to number of trees. The value of trees on improved property increased by $83 per acre with each $1,000 increase in the current market value of homeowner's mountain property. Many construction workers have built their own homes in the Front Range of Colorado, which contributes to sensitivity to the number of trees on neighboring mountain property. Workers valued trees on unimproved property by nearly $2,743 per acre more than other mountain homeowners. The value of trees on mountain property cannot be attributed to the size of houses. The value of trees decreased by $1,017 per acre with each additional bedroom in mountain homes. Thus, those with smaller mountain homes valued trees more highly on the property than those with larger homes. The consumer surplus benefit from mountain home living contributed to willingness to pay for trees. The value of trees on improved property increased by nearly $27 per acre with each additional $1 of consumer surplus benefit per

day. However, the total willingness to pay for mountain home living did not contribute to the value of trees on improved property. The value of trees increased by $700 per acre with each $100 decrease in willingness to pay per month to live in the mountains. This reflects the fact that those with higher willingness to pay also had higher cost of living and lower consumer surplus benefit.

Those who purchased or moved to Front Range mountain property in recent years were more sensitive to number of trees than those who have lived there for many years. The value of trees on improved property increased by $100 per acre with one year decrease in number of years lived in the study area. The value of trees on unimproved property increased by $117 per acre with one year decrease in mountain property ownership.

Tastes and preferences also were associated with sensitivity to the number of trees on Front Range mountain property. The value of trees on unimproved property increased by $2,546 per acre with one unit increase in the relative preference for trees relative to rock outcroppings on a five-point scale with one most important and five least. The value of trees on improved property increased by $1,996 per acre with one unit increase in the preference for trees on adjacent property compared to $2,264 per acre on unimproved property. The value of trees on unimproved property increased by $1,015 per acre with one unit increase in the preference for trees in the far view.

The value of trees on property in Front Range forests cannot be attributed to active environmentalists who live in the study area. In fact, the value of trees was $6,620 per acre less for members of environmental organizations. Years of education also contributed to sensitivity to trees on mountain property. The value of trees on unimproved property increased by $314 per acre with each one year increase in education.

TREES ON ADJACENT PROPERTY

Figure 6 and Table 8 show change in the contribution of trees to improved mountain property values with changes in number of live trees six inches dbh or more on adjacent property. It was estimated that the contribution of trees to the value of mountain property would decrease by -0.20 percent with a one percent decrease in the number of trees an adjacent property. This average or arc elasticity of property values with respect to number of trees on adjacent property was calculated in the range of 1-15 percent decrease from 212 trees per acre on adjacent property, all other variables unchanged. This represents the external cost of mountain pine beetle infestation which reduces the number of trees in the neighborhood of improved mountain property.

Ordinary least squares statistical methods were used to estimate the relationship of property value to number of trees on adjacent property and other social economic variables. The dependent variable was the change in the contribution of trees to the value of improved mountain property. The sample of 64 mountain homeowners reported their maximum willingness to pay for one-acre tracts of improved mountain property contingent on changes in the number of trees six inches dbh or more on adjacent property in the near view. Number of trees was illustrated by four color photos of low, medium and high trees per acre. This resulted in a total of 256 observations of the relationship between improved property values and trees on adjacent property, which was sufficient for statistically significant analysis. The proportion of variation in the value explained by the independent variables included in the equation was .36 as measured by R^2 adjusted for degrees of freedom. All regression coefficients were significantly different from zero at the 0.00 to 0.10 confidence level. The overall equation

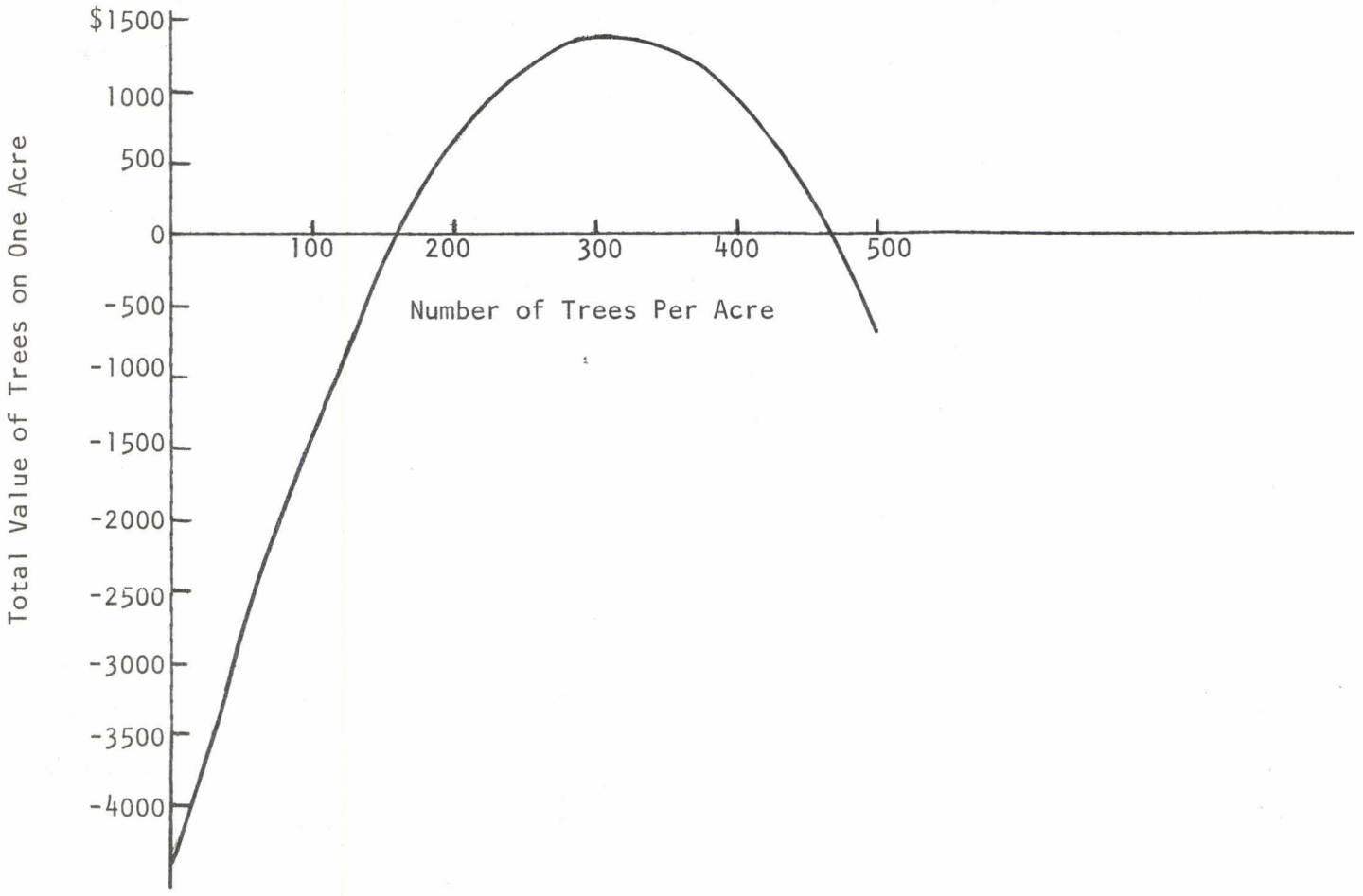


Figure 6. Change in Value of Trees on Improved One-Acre Tracts Contingent on Changes in the Number of Trees on Adjacent Property in the New View, Mountain Homeowners, Front Range, Colorado, 1980.

Table 8. Change in Value of Trees on Improved One-Acre Tracts Contingent on Changes in the Number of Trees on Adjacent Property in the Near View, Mountain Homeowners, Front Range, Colorado, 1980.

Number of Trees Per Acre	Total Value of Trees on One Acre
10	-$4,098
25	- 3,567
50	- 2,742
75	- 1,992
100	- 1,317
125	- 717
150	- 192
175	258
200	633
225	933
250	1,158
275	1,308
300	1,383
325	1,383
350	1,308
375	1,158
400	933
425	633
450	258
475	- 192
500	- 717

was statistically significant at the 0.01 level as indicated by an F value of 12.75. Alternative forms of the equation were tried including the linear, quadratic, and logarithmic forms, with the quadratic model which includes a linear and a squared term providing the best fit of the relationship of interest. The usual tests of the assumptions of the regression model revealed no significant effects on the study results.

The stepwise multiple regression technique was used to estimate the coefficients and the constant of the model. The general equations were condensed to show the relationship between the two variables of interest. All independent variables other than number of trees on adjacent property and number of trees squared were multiplied by their means and added to the constant. The following reduced function was obtained for the relationship between the number of trees on adjacent property and the contribution of trees to the value (in $100s) of improved mountain property:

$$\begin{array}{l}\text{Contribution of trees}\\ \text{to the value of}\\ \text{improved property}\end{array} = -44.6689 = 0.3750\text{TREES} - 0.0006\text{TREES}^2$$

This equation indicates that the contribution of trees to the value of improved mountain property falls by $4,467 per acre when there are no trees on adjacent property. With otherwise identical conditions, the contribution of trees on adjacent property to the value of mountain property increases by nearly $38 per additional tree on adjacent property and decreases by $0.06 per additional tree squared. The resulting function provides a reasonable representation of the effect of adjacent trees on values in the lower to mid-range which is the relevant area of decision making. The function should not be taken to the extreme of very large numbers of trees which represents an extrapolation as few observations were taken beyond 300 trees per acre.

Figure 6 and Table 8 show that the resulting total value function was inverted U-shaped. The total contribution of trees to the value of improved mountain property would fall by $4,098 per acre with 10 trees per acre on adjacent property, by $2,742 with 50 trees per acre, by $1,317 with 100 trees per acre, and by $192 with 150 trees per acre. The total contribution of trees to the value of improved mountain property would increase by $633 per acre with 200 trees per acre on adjacent property, by $1,158 with 250 trees per acre, and reaches a maximum of $1,392 with 312 trees per acre. Thereafter, the total contribution of trees to the value of improved mountain property would decline with additional trees on adjacent property. Indications are that beyond 465 trees per acre on adjacent property, additional trees would reduce the contribution of trees to the value of improved mountain property, although this is an extrapolation as few observations were taken at these levels.

Other social economic variables shift the vertical intercept of the function relating the contribution of trees to improved property values and number of trees on adjacent property. Table 9 shows the variables which were significantly related to the value of trees. Those which were positively associated with tree values include: annual days of outdoor recreation, annual days of vacation, year mountain home built, size of property in acres, total willingness to pay per month to live in mountain home, sex female, and the taste variable, importance of trees relative to topography. Variables which were negatively associated with tree values include: household income, current market value of mountain property, and worth more than cost to live in mountain home. Other variables which were tried and found not significantly associated with tree values include: total monthly housing cost, family size, age, years lived in

Table 9. Ordinary Least Square Equation Estimates of the Value of Trees on Improved One-Acre Tracts, Contingent on Variations in Number of Trees Six Inches dbh or More on Adjacent Property in the Near View, Mountain Homeowners, Front Range, Colorado, 1980.

Independent Variables	Regression Coefficients[a]
Number of Trees on One Acre Tract	0.3750 (4.25)
Number of Trees on One Acre Tract, squared	-0.0006 (-1.92)
Worth More Than Cost to Live in Mountain Home; 1=yes, 2=no	28.9689 (3.35)
Sex; 1=male, 2=female	34.6553 (4.67)
Annual Days of Outdoor Recreation	0.1035 (2.55)
Annual Days of Vacation	0.2077 (3.99)
Year Mountain Home Built	0.8259 (3.85)
Total Willingness to Pay to Live in Mountain Home	0.0281 (4.73)
Current Market Value of Property, thousands	-0.3703 (-2.57)
Size of Property in Acres	4.2282 (3.48)
Annual Household Income, thousands	-0.3819 (-2.60)
Importance of Trees Relative to Topography, 5-point scale	-7.5062 (-1.85)
Constant	-162.8671 (-6.78)
Adjusted R^2	.36
F Significance	12.75
Number of Observations	256

a. Numbers in parentheses below each coefficient represent student t-ratios for the null hypothesis. All variables are at the .00 to .10 confidence levels.

study area, years of mountain property ownership, number of bedrooms, membership in an environmental or sportsman's organization, consumer surplus benefit of mountain home living, years of education, employment as a worker, for the government, as a professional or manager, retired, preference for trees relative to rock outcroppings, view of the mountains, and nearness to streams and lakes, and preference for trees on the property, on adjacent property, and in the far view.

Other important variables were controlled independent of the regression analysis. The willingness to pay questions assumed that the mountain property shown in the color pictures were exactly the same except for the number of trees. Size of lot was held constant at one acre, roughly 200 x 200 feet. Ponderosa pine trees were in a scattered arrangement. Topography was specified as gently sloping land with little or no rolls. Access was by public road in front of the property. All schools were equally close and lots were in the same subdivision in the study areas in Front Range forests. Utilities included electricity, sewer and water were available in front of the lot. The house was valued at $80,000 and included 1,500 to 2,000 feet of living space, two baths, two-car garage, fireplace, three bedrooms, and a family room. Lot value averaged $10,000 $20,000 consistent with values reported in the study areas.

Leisure time to engage in outdoor recreation contributed to knowledge of forest conditions and sensitivity to the number of trees on adjacent mountain property. As expected, tree values increased by $10 with each edditional day of outdoor recreation per year. Annual days of vacation also contributed. The value of trees increased by nearly $21 with one additional day of annual vacation. Women were more sensitive to the number of trees on adjacent property than men. The effect of trees in the adjacent forest on the value of improved

property was $3,466 per acre more for women than men. This reflects the fact that housewives were often at home during the day which contributed to their knowledge of forest conditions and sensitivity to the number of trees on adjacent property.

Sensitivity to number of trees in the near view from mountain homes on the Front Range was negatively associated with annual household income although the effect was small. The effect of trees in the adjacent forest on the value of improved mountain property increased by $38 with a $1,000 decrease in household income. This means that the effect on tree values was greater for middle class households than those with higher incomes which enabled them to travel to alternative recreation sites without insect damage to trees in the near view. This possibility was consistant with the fact that sensitivity to the number of trees in the near view was negatively associated with the market value of mountain property, although the effect was also small. The effect of trees in the adjacent forest on the contribution of trees to value of improved mountain property increased $37 per acre with each $1,000 decrease in the current market value of mountain property.

Total willingness to pay for mountain home living contributed to sensitivity to trees on adjacent property. The effect on tree values increased by $281 with each $100 increase in willingness to pay per month to live in the mountains. However, those who reported that it was not worth more than actual cost to live in mountain homes on the Front Range were also sensitive to trees on adjacent property. The effect on tree values was $2,897 per acre more for those who reported that living in a mountain home was not worth more than its cost. This may reflect the fact that those with higher willingness to pay also had had higher cost of living. Moreover, they may have experienced loss of amenity values from forest insect damage to trees in the adjacent forest.

Individuals living in Front Range mountain homes built in recent years were more sensitive to number of trees on adjacent property than those living in older homes. The value of trees on improved property increased by $83 with one year decrease in number of years since construction of mountain home.

The size of a homeowner's property contributed to sensitivity to number of trees on adjacent property. The value of improved property increased by $423 per acre with each additional acre of mountain property.

Tastes and preferences also were associated with sensitivity to the number of trees adjacent to Front Range mountain property. The value of trees on improved property increased by $750 with one unit increase in the relative preference for trees relative to topography on a five-point scale with one most important and five least.

SIZE OF TREES

Figure 7 and Table 10 show the effect of size of trees on the value of improved and unimproved mountain property. It was estimated that the value of trees per acre would decrease by -0.35 percent with a one percent decrease in the size of trees surviving mountain pine beetle infestation on improved mountain property, compared to -0.32 percent on unimproved mountain property. These average or arc elasticities of tree values with respect to size were based on observations in the range of 3-12 inches dbh. This represents the effect of forest insect infestation which decreases the average size of surviving live trees. In a later section of this report, the statistical analysis of the effect of tree size on property values will be utilized to show that with reforestation after forest insect infestation, property values would rise over the growth cycle of ponderosa pine. This is an important consideration when calculating the present value of benefits from a forest insect control program over a planning period of 50 to 100 years.

Ordinary least squares statistical methods were used to estimate the relationship of property value to the size of trees and other social economic variables. The dependent variable was the contribution of tree size to the value of mountain property. The sample of 64 homeowners reported their maximum willingness to pay for improved and unimproved mountain property contingent on changes in the size of trees from six inches dbh to three inches dbh and to twelve inches dbh. Size of trees was illustrated by color photos. This resulted in a total of 192 observations of the relationship between tree values and size, which was sufficient for statistically significant analysis. The proportion of variation in the value of trees explained by the independent variables included in the

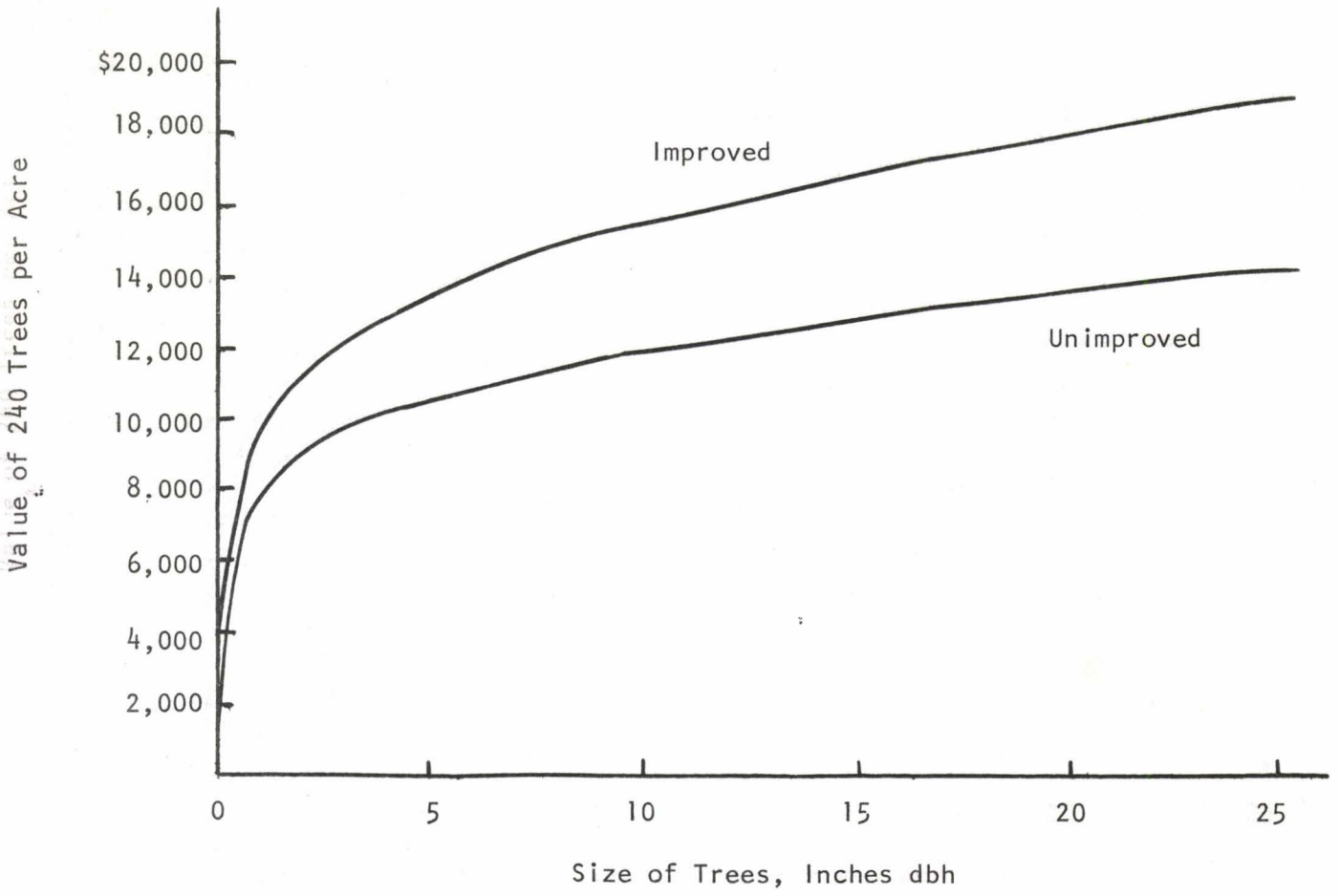


Figure 7. Value of Trees on Improved and Unimproved One Acre Tracts Contingent on Changes in the Size of Trees, Mountain Homeowners, Front Range, Colorado, 1980.

Table 10. Value of Trees on Improved and Unimproved One Acre Tracts Contingent on Changes in the Size of Trees, Mountain Homeowners, Front Range, Colorado, 1980.

Size of Trees, Inches dbh	Value of 240 Trees Per Acre[a]	
	Improved	Unimproved
1	$ 9,824	$ 8,263
2	11,020	9,102
3	12,155	9,680
4	12,876	10,135
5	13,472	10,516
6	13,984	10,847
7	14,434	11,142
8	14,840	11,408
9	15,208	11,652
10	15,546	11,877
11	15,860	12,087
12	16,153	12,285
15	16,934	12,815
18	17,604	13,275
21	18,195	13,684
24	18,725	14,055

a. From equations shown as Table forced through the means of the value of trees.

equations was .18 and .20 as measured by R^2 adjusted for degrees of freedom. All regression coefficients were significant at the 0.00 to 0.10 confidence levels. The overall equations were statistically significant at the 0.01 level as indicated by F values of 6.29 and 7.45. Alternative forms of the equations were tried including linear, quadratic, and logarithmic forms with the double logarithmic model providing the best fit of the relationship of interest. The usual tests of the assumptions of the regression model revealed no significant effects on the study results.

The stepwise multiple regression technique was used to estimate the coefficients and the constant for the model. The general equations were condensed to show the relationship between the two variables of interest. All independent variables other than the log of tree size were multiplied by their means and added to the constant. The following power functions were obtained for the relationship between tree size and the value of trees (in $100s) on improved and unimproved mountain property:

$$\text{Willingness to pay for trees on improved property} = 75.2187\ (\text{SIZE})^{.2457} + 23.02$$

$$\text{Willingness to pay for trees on unimproved property} = 36.2667\ (\text{SIZE})^{.3003} + 46.36$$

As expected, these equations indicate that tree size contributed more value to improved property than to unimproved. With otherwise identical conditions, the value of trees on improved mountain property increased by 0.25 percent with one percent increase in the tree size, compared to 0.30 percent on unimproved property. The resulting functions provide a reasonable representation of the effect of tree size on property values in the mid-range of size which is the most relevant area of decision making. However, the functions should not be

taken to the extreme of very large tree size. The latter represents an extrapolation as no observations were taken beyond 12 inches dbh.

Figure 7 and Table 10 show that the resulting total value functions rise at an increasing and then decreasing rate over the range of size considered, from 1 to 24 inches dbh. The total value of 240 trees on improved mountain property increased from $12,155 per acre with trees three inches dbh, to $13,984 per acre with trees six inches dbh, to $16,153 with trees 12 inches dbh, and to $18,725 with trees 24 inches dbh. This compared to the total value of 240 trees on unimproved mountain property which increased from $9,680 per acre with trees three inches dbh, to $10,847 per acre with trees six inches dbh, to $12,285 with trees 12 inches dbh, and to $14,055 with trees 24 inches dbh. Thus, tree size contributed nearly $2,475 more value to improved than to unimproved property with trees 3 inches dbh, $3,137 more value with trees 6 inches dbh, $3,868 more value with trees 12 inches dbh, and $4,670 more value with trees 24 inches dbh.

Other variables shift the vertical intercept of the functions relating property value to tree size. Table 11 shows the social economic variables which were significantly related to property values. Variables which were positively associated with property values include: annual days of outdoor recreation, market value of the property, number of bedrooms, worth more than cost to live in mountain home, member of sportsman's organization, employment as a worker, and preference variables including the importance of trees relative to topography, on adjoining property, and in the far view. Variables which were negatively related to property values include: education, sex, and total monthly housing cost. Other variables which were tried and found not significantly associated with the tree size value function include: years of mountain property ownership,

Table 11. Ordinary Least Square Equation Estimates of the Value of Trees on Improved and Unimproved One Acre Tracts Contingent on Changes in the Size of Trees, Mountain Homeowners, Front Range, Colorado, 1980.

Independent Variables	Regression Coefficients[a]	
	Improved[b]	Unimproved[c]
Log of Tree Size, inches dbh	0.2457 (2.50)	0.3003 (2.44)
Importance of Trees on Adjoining Property, 5-point scale	-0.3117 (-3.55)	
Importance of Trees in Far View, 5-point scale		-0.6628 (-4.03)
Importance of Trees Relative to Topography, 5-point scale		-0.7956 (-3.47)
Sex, 1=male; 2=female	-0.2966 (-2.19)	-0.7357 (-3.10)
Worth More than Cost to Live in Mountain Home, 1=yes; 2=no		-1.0757 (-2.98)
Annual Days of Outdoor Recreation	0.0015 (1.94)	
Number of Bedrooms in Mountain Home	0.1811 (2.16)	-0.6410 (-2.92)
Member of Sportman's Organization, 1=yes; 2=no		-0.4735 (-1.85)
Worker, 1=yes; 0=no	0.5004 (3.16)	
Number of Years of Formal Education		-0.6588 (-1.66)
Total Monthly Housing Cost	-0.000648 (-3.21)	
Current Market Value of Property, thousands	0.0027 (1.64)	
Constant	4.5698 (11.88)	7.6700 (6.20)
Adjusted R^2	.18	.20
F Significance	6.29	7.45
Number of Observations	192	192

a. Number in parentheses below each coefficient represents student t-ratios for the null hypothesis. All variables are significant at the .00 to .10 confidence levels.
b. With the dependent variable and the tree size independent variable in log form and all other independent variables in linear form.
c. Double log function with the dependent and all independent variables in log form.

years lived in study area, size of property, calendar year mountain home built, family size, total willingness to pay to live in mountain home, annual days of vacation, age, membership in an environmental organization, average household income, consumer surplus benefit of mountain home living, housewife, government employee, professional or manager, retired, and preference variables including importance of trees relative to rock outcroppings, proximity to streams and lakes, and view of the mountains.

Other important variables were controlled independent of the regression analysis. The willingness to pay questions assumed that the mountain property shown in the color pictures were exactly the same except for the size of trees. Size of lot was held constant at one acre, roughly 200 x 200 feet. Ponderosa pine trees were in a scattered arrangement. Topography was specified as gently sloping land with little or no rolls. Access was by public road in front of the property. All schools were equally close and lots were in the same subdivision in the study areas in Front Range forests. Utilities included electricity, sewer and water were available in front of the lot. The house was valued at $80,000 and included 1,500 to 2,000 feet of living space, two baths, two-car garage, fireplace, three bedrooms, and a family room. Lot value averaged $10,000-$20,000 consistent with values reported in the study areas.

Leisure time to engage in outdoor recreation contributed to knowledge of forest conditions and sensitivity to the size of trees on mountain property. As expected, the value of tree size on improved property increased by nearly 1.5 percent with each 10 day increase in outdoor recreation per year.

The market value of homeowner's property contributed to sensitivity to tree size. The value of tree size on improved property increased by nearly 2.7 percent with a $10,000 increase in the current market value of homeowner's mountain property. Those with larger mountain homes valued tree size on improved property more highly than those with smaller homes, however, the reverse was true for unimproved property. The value of tree size on improved property increased by 1&1 percent with each additional bedroom in mountain homes, and decreased for unimproved property.

Many construction workers have built their own homes in the Front Range of Colorado, which contributed to sensitivity to the size of trees. Workers valued tree size on improved property by nearly 50.0 percent more than other mountain homeowners. Men were more sensitive to size of trees than women. The value of tree size on improved mountain property was 29.7 percent more for men than women, compared to 73.6 percent more on unimproved property. High school graduates with some college or professional school were more sensitive to the value of tree size than college graduates. The value of tree size on unimproved mountain property decreased by 0.66 percent with each one percent increase in years of education. Member of sportsman's organizations were more sensitive to the size of trees on Front Range mountain property than other homeowners. The value of tree size on unimproved mountain property was 47.4 percent higher for members of sportsman's organizations.

Consumer surplus benefit from mountain home living contributed to the value of tree size on Front Range mountain property. Homeowners who reported that it was worth more than cost to live in a mountain home valued tree size on unimproved mountain property by 107.6 percent more than other homeowners. However, those with high monthly housing cost valued tree size less than homeowners with lower

cost although the effect was small. The value of tree size on improved mountain property fell by about 6.5 percent with a $100 increase in total monthly housing cost.

Tastes and preferences also were associated with sensitivity to tree size on Front Range mountain property. The value of tree size on unimproved property increased by 0.80 percent with one percent increase in the relative preference for trees relative to topography on a five-point scale with one most important and five least. The value of tree size on improved property increased by 31.2 percent with one unit increase in the preference for trees on adjacent property, compared to unimproved property with an increase of 0.66 percent for one percent increase in importance of trees in the far view.

EXPECTATION OF INSECT DAMAGE

Table 12 shows the effect of a general outbreak of severe insect infestation when forest entomologists predict that 50 percent of the trees on mountain property will be killed within five years. During the past decade, mountain homeowners in several parts of the Front Range of the Rocky Mountains in Colorado were confronted with the probability of such a large loss in number of trees on their property. Expectation of future insect damage would lead to immediate discount of the present value of both improved and unimproved mountain property, in anticipation of future damage to forest quality. Value of trees per acre would decrease by -0.76 percent with each one percent increase in expected insect damage to trees on improved mountain property. The average elasticity of tree values with respect to expected insect damage was calculated as -0.76 in the range of 1-50 percent of 212 trees per acre on improved mountain property, all other variables unchanged.

The effect of expected future insect damage was less on unimproved mountain property. Value of trees per acre would decrease by -0.61 percent with each one percent increase in expected insect damage to trees on unimproved mountain property. This suggests that mountain homeowners believe that a general outbreak of forest insect infestation would have a general effect on the value of all mountain property, both improved and unimproved.

Table 13 shows the significant social and economic variables associated with the effect of expected future insect damage on the contribution of trees to value of improved and unimproved mountain property. Number of observations included in the regression model was 64, which was sufficient for statistically significant analysis. The proportion of the variation in contribution of trees

Table 12. Value of Trees to Mountain Homeowners if Forest Entomologists Predict that 50 Percent of Trees will be Killed by Insect Infestation Within Five Years, Front Range, Colorado, 1980.

Change in Expectations	Value of 212 Trees Per Acre	
	Improved	Unimproved
Without Expectation of Forest Insect Infestation	$15,297 (8,856)[b]	$11,093 (7,436)
With Expectation that 50 Percent of Trees will be Killed Within Five Years	$ 9,484 (10,154)	$ 7,719 (7,224)
Change in Value	-$ 5,813	-$ 3,374
Percent Change	-38.0	-30.42
Elasticity[a]	- 0.76	- 0.61

a. Average elasticity calculated as percent change in value of trees divided by 50 percent change in number of live trees in five years.

b. Standard deviation in parentheses.

Table 13. Ordinary Least Square Equation Estimates of the Value of Trees to Mountain Homeowners if Forest Entomologists Predict that 50 Percent of Trees will be Killed by Insect Infestation within Five Years, Front Range, Colorado, 1980.

Independent Variables	Regression Coefficients[a]	
	Improved	Unimproved
Importance of Trees on Property, 5-point scale	-56.0723 (-2.35)	
Importance of Trees Relative to Rocky Mountain View, 5 point scale	-25.7260 (-1.71)	
Year Mountain Home Built		-2.0567 (-4.30)
Sex, 1=male; 2=female		-39.4966 (-2.14)
Total Monthly Housing Cost		-0.0699 (-2.81)
Housewife, 1=yes; 0-no	-128.0110 (-3.26)	
Constant	255.4225 (4.97)	287.2346 (6.39)
Adjusted R^2	.20	.27
F Significance	6.29	8.74
Number of Observations	64	64

a. Numbers in parentheses below each coefficient represent student t-ratios for the null hypothesis. All variables are significant at the .00 to .10 confidence levels.

to property values explained by the independent variables included in the equations was .20 and .27 as measured by R^2 adjusted for degrees of freedom. All regression coefficients were significantly different from zero at the 0.01 to 0.10 level. The overall equations were statistically significant at the 0.01 level as indicated by F values of 6.29 and 8.74. The usual tests of the assumptions of the linear regression model revealed no significant effects on the study results.

Ordinary least squares statistical methods were used to estimate the coefficients and the constant of the general equations. Variables which were positively associated with change in trees values resulting from an expected 50 percent future insect damage included: the preference variables, importance of trees relative to view of the mountains, and importance of trees on the property. Variables which were negatively associated with change in tree values include: year mountain home built, sex female, housewife, and total monthly housing cost. Other social and economic variables which were tried and found not significantly associated with the effect of expected future insect damage on tree values include: annual household income, family size, age, years lived in study area, age of mountain home, current market value of property, member of environmental or sportsman's organization, size of property in acres, number of bedrooms, years of mountain property ownership, willingness to pay to live in a mountain home, consumer surplus benefit of mountain home living, annual days of outdoor recreation, annual days of vacation, years of education, employment as a worker, for the government, as a professional or manager, retired; preference for trees relative to topography, rock outcroppings, and nearness to streams and lakes; and preference for trees on adjacent property, and in the near view.

Other important variables were controlled independent of the regression analysis. The willingness to pay questions assumed that the mountain property shown in the color pictures were exactly the same except for forest quality. Ponderosa pine trees were in a scattered arrangement. The size of lot was held constant at one acre, roughly 200 x 200 feet. Topography was specified as gently sloping land was little or no rolls. Access was by public road in front of the property. All schools were equally close and lots were in the same subdivision located in the Front Range of Colorado. Available utilities included electricity, sewer and water in front of the lot. The house was valued at $80,000 and included 1,500 to 2,000 square feet of living space, two baths, two-car garage, fireplace, three bedrooms, and a family room. Land value was $10,000-$20,000 for a one-acre tract. Both house and lot values were consistent with values reported in the study area.

Women were more sensitive to expected insect damage to trees on mountain property than men. The effect of expected insect damage on tree values was $3,950 per acre of unimproved property more for women than men. It was $12,801 per acre of improved property more for housewives than those employed in other occupations. This reflects the fact that housewives were often at home during the day which contributed to their knowledge of forest conditions and sensitivity to expected insect damage of trees on mountain property.

Individuals whose total monthly housing cost was less than average were more sensitive to the effect of expected insect damage on tree values than those whose cost was higher. The effect of expected insect damage on tree values increased by nearly $70 per acre of unimproved mountain property with each $10 decrease in monthly housing cost. Individuals living in Front Range mountain

homes built in recent years were more sensitive to expected insect damage than those living in older homes. The effect of expected insect damage on tree values increased by $206 per acre of unimproved property with one year decrease in number of years since construction of mountain homes.

Tastes and preference also were associated with sensitivity to expected insect damage to Front Range mountain property. The effect on tree values increased by $2,573 per acre of improved mountain property with one unit increase in the relative preference for trees relative to view of the mountains on a five-point scale with one most important and five least. The effect of expected insect damage on tree values increased by $5,607 per acre of improved mountain property with one unit increase in the importance of trees on mountain property.

VISIBLE INSECT DAMAGE

Table 14 shows the effect of visible insect damage on mountain property values during the second year after a mountain pine beetle attack when needles appear rust colored on dying trees. It would be the annual effect of spruce budworm infestation of douglas fir. Value of trees per acre would decrease by a reported -2.27 percent with visible beetle damage to one percent of the trees on improved mountain property. The elasticity of tree values with respect to visible insect damage was calculated as -2.27 percent in the range of 1-15 percent of 212 trees per acre with pine beetle damage on improved mountain property all other variables unchanged.

The effect of visible insect damage would be somewhat less on unimproved mountain property. Value of trees per acre would decrease by-1.80 percent with visible insect damage to one percent of the trees on unimproved mountain property, or by 0.47 percentage points less than for improved mountain property. Prospective buyers may postpone the purchase of subdivision lots with visible beetle damage until evidence of the insect infestation has been removed. For owners of improved mountain property, visible beetle damage is a daily reminder of the loss in forest value during the second year after a mountain pine beetle attack.

Table 15 shows the significant social and economic variables associated with change in the contribution of trees to mountain property values with visible insect damage to 15 percent of the trees on improved and unimproved property. Number of observations included in the regression models was 64, which was sufficient for statistically significant analysis. The proportion of the variation in contribution of trees to property values explained by the independent variables included in the equations was .35 and .36 as measured by R^2 adjusted

Table 14. Change in the Value of Trees to Mountain Homeowners with Visible Insect Damage to 15 Percent of Trees, Front Range, Colorado, 1980.

With and Without	Value of 212 Trees Per Acre Six Inches dbh or More	
	Improved	Unimproved
Without Visible Beetle Damage	$15,297 (8,856)[b]	$11,093 (7,436)
With 15 Percent Visible Beetle Damage	$10,079 (6,507)	$ 8,092 (6,774)
Change in Value	-$ 5,218	-$ 3,001
Percent Change	-34.11	-27.05
Elasticity[a]	- 2.27	- 1.80

a. Average elasticity calculated as percent change in value of trees divided by 15 percent change in visible beetle damage.

b. Standard deviation in parentheses.

Table 15. Ordinary Least Square Equation Estimates of the Value of Trees to Mountain Homeowners with Visible Insect Damage to 15 Percent of Trees, Front Range, Colorado, 1980.

Independent Variables	Regression Coefficients[a]	
	Improved	Unimproved
Years of Mountain Property Ownership	-3.6335 (-3.19)	-3.1902 (-2.96)
Year Mountain Home Built	-1.0909 (-2.26)	-0.8421 (-1.84)
Importance of Trees Relative to Rock Outcroppings, 5-point scale		-20.2297 (-2.00)
Importance of Trees Relative to Topography, 5-point scale	-37.9795 (-3.72)	-20.3471 (-2.07)
Current Market Value of Property, thousands	0.9396 (3.41)	1.0566 (3.97)
Size of Property in Acres		-5.7932 (-2.35)
Sex, 1=male; 2=female	32.7231 (1.91)	
Total Willingness to Pay to Live in Mountain Home	-0.0716 (-4.76)	
Total Monthly Housing Cost		-0.1152 (-4.01)
Member of Environmental Organization, 1=yes; 2=no	-61.4533 (-2.70)	
Surplus Value of Mountain Home Living		-0.1261 (-1.89)
Constant	312.3531 (4.48)	221.3259 (4.62)
Adjusted R^2	.36	.35
F Significance	6.04	5.21
Number of Observations	64	64

a. Numbers in parentheses below each coefficient represent student t-ratios for the null hypothesis. All variables are significant at the .00 to .10 confidence levels.

for degrees of freedom. All regression coefficients were significantly different from zero at the 0.01 to 0.10 level. The overall equations were statistically significant at the 0.01 level as indicated by F values of 5.21 and 6.04. The usual tests of the assumptions of the linear regression model revealed no significant effects on the study results.

Ordinary least squares statistical methods were used to estimate the coefficients and the constants of the general equations. Variables which were positively associated with the change in contribution of trees to property values resulting from visible insect damage include: age of mountain home, current market value of property, sex female, member of environmental organization, and preference for trees relative to topography and rock outcroppings. Variables which were negatively associated with the change in contribution of trees to property values include: size of property in acres, years of mountain property ownership, willingness to pay to live in a mountain home, monthly housing cost, and consumer surplus benefit of mountain home living. Other social and economic variables which were tried and found not significantly associated with the effect of visible insect damage on the contribution of trees to property values include: annual days of outdoor recreation, annual days of vacation, household income, worth more than cost to live in mountain home, family size, age, years lived in the study area, number of bedrooms, membership in a sportsman's organization, years of education, employment as a worker, for the government, as a professional or manager, retired; preference for trees relative to view of the mountains, nearness to streams and lakes; and preference for trees on the property, on adjacent property, and in the near view.

Other important variables were controled independent of the regression analysis. The willingness to pay questions assumed that the mountain property shown

in the color pictures were exactly the same except for forest quality. Ponderosa pine trees were in a scattered arrangement. The size of lot was held constant at one acre, roughly 200 x 200 feet. Topography was specified as gently sloping land with little or no rolls. Access was by public road in front of the property. All schools were equally close and lots were in the same subdivision located in the Front Range of Colorado. Available utilities included electricity, sewer and water in front of the lot. The house was valued at $80,000 and included 1,500 to 2,000 square feet of living space, two baths, two-car garage, fireplace, three bedrooms, and a family room. Land value was $10,000-$20,000 for a one-acre tract. Both house and lot values were consistent with values reported in the study area.

The effect of visible insect damage was positively associated with the market value of mountain property. The effect of visible insect damage on tree values increased by nearly $94 per acre of improved mountain property with each $1,000 increase in market value, compared to $106 per acre of unimproved mountain property with each $1,000 increase in market value. Individuals living in Front Range mountain homes built in recent years were more sensitive to visible insect damage than those living in older homes. The effect of visible insect damage on tree values increased by $109 per acre with one year decrease in number of years since construction of mountain homes. This was consistent with the finding that years of mountain property ownership was negatively associated with the effect of visible insect damage on tree values. The contribution of trees to the value of improved mountain property decreased by $363 per acre with each additional year of mountain property ownership, compared to a decrease of $319 per acre of unimproved mountain property. Increases in the size of tracts was negatively

associated with the effect of visible insect damage on tree values. The effect of visible insect damage on tree values decreased by $579 per acre of unimproved mountain property with each additional acre.

Individuals whose total monthly cost, willingness to pay, and consumer surplus benefit of mountain home living was less than average were more sensitive to the effect visible insect damage on tree values than those whose cost, willingness to pay, and consumer surplus was higher. The effect of visible insect damage on tree values increased by nearly $115 per acre of unimproved mountain property with each $10 decrease in monthly housing cost. The effect of insect damage increased by $72 per acre of improved mountain property with each $10 decrease in willingness to pay per month to live in a mountain home. The effect of insect damage increased by nearly $13 per acre of unimproved mountain property with each $1 decrease in consumer surplus value per day of mountain home living.

Women were more sensitive to visible insect damage to trees on mountain property than men. The effect of visible insect damage on tree values was $3,272 per acre more for women than men. This reflects the fact that housewives were often at home during the day which contributed to their knowledge of forest conditions and sensitivity to visible forest insect damage to trees on mountain property.

Tastes and preferences also were associated with sensitivity to visible insect damage on Front Range mountain property. The effect on tree values increased by $3,798 per acre of improved mountain property with one unit increase in the relative preference for trees relative to topography on a five-point scale with one most important and five least, and increased by $2,035 per acre of unimproved mountain property. The effect of visible insect damage on tree values

increased by $2,023 per acre of unimproved mountain property with one unit increase in the relative preference for trees relative to rock outcroppings. As expected, some groups were more sensitive to visible insect damage than others. The effect of visible insect damage on tree values was $6,145 per acre more for members of environmental organizations than other groups.

SPECIMEN TREES

Table 16 shows the effect of specimen trees 24 inches dbh or more on mountain property values. Mountain pine beetles frequently have attacked these large mature trees which are very scarce in the cutover forest on the Front Range of the Rocky Mountains. Value of trees per acre would decrease by a reported -3.64 percent with the loss of one percent specimen trees (2.4 trees per acre) on improved mountain property. The average or arc elasticity of tree values with respect to specimen trees was calculated as -3.64 percent in the range of 1-5 percent of 212 trees per acre, with all other variables unchanged. It should be noted that this analysis assumes that the reduction in value from a loss of large specimen trees would equal the reported increase in the value from their presence or gain. The elasticity of tree values with respect to loss of specimen trees is shown along with their gain in Table 16.

The effect of the loss of specimen trees was somewhat less on unimproved mountain property. Value of trees per acre would decrease by -2.61 percent with the loss of one percent specimen trees on unimproved mountain property, or 1.03 percentage points less than on improved mountain property. Once the dead specimen trees are removed, it is unlikely that most prospective buyers would be aware that an insect attack ever occurred in the area. The fact remains, however, that in a subdivision where insect damage has occurred, the value of the trees will be significantly different from what it would have been in the absence of the insect damage. Thus, property values will be reduced with the loss of specimen trees. Owners of improved mountain property would be accutely aware of the aesthetic beauty of live specimen trees and would suffer the greatest loss in value from their removal by mountain pine beetle infestation.

Table 16. Change in the Value of Trees to Mountain Homeowners with Five Percent Specimen Trees 24 Inches dbh or More, Front Range, Colorado, 1980.

With and Without Specimen Trees	Value of 212 Trees Per Acre Six Inches dbh or More	
	Improved	Unimproved
Without Specimen Trees	$15,297 (8,856)[b]	$11,093 (7,436)
With Five Percent Specimen Trees	$18,700 (12,399)	$12,758 (7,655)
Change in Value	$ 3,403	$ 1,665
Percent Change, Increase	22.25	15.01
Decrease	18.20	13.05
Elasticity[a], Increase	4.45	3.00
Decrease	3.64[c]	2.61

a. Average elasticity calculated as percent change in value of trees divided by 5 percent change in number of specimen trees, 24 inches dbh or more.

b. Standard deviation in parentheses.

c. Elasticity of tree values with respect to loss of specimen trees is shown in parentheses.

Table 17 shows the significant social and economic variables associated with the value of trees when forest insects kill the five percent specimen trees on unimproved mountain property. Number of observations included in the regression model was 64, which was sufficient for statistically significant analysis. The proportion of the variation in trees values explained by the independent variables included in the equation was .22 as measured by R^2 adjusted for degrees of freedom. All regression coefficients were significantly different from zero at the 0.01 to 0.10 level. The overall equation was statistically significant at the 0.01 level as indicated by an F value of 6.90. The usual tests of the assumptions of the linear regression model revealed no significant effects on the study results.

Ordinary least squares statistical methods were used to estimate the coefficients and the constant of the general equation. Variables which were positively associated with change in trees values from a loss of five percent specimen trees included: importance of trees in the far view, worth more than cost to live in mountain home, sex male, and member of sportsman's organization. Other social and economic variables which were tried and found not significantly associated with the effect of losing five percent specimen trees include: annual household income, family size, age, years lived in study area, age of mountain home, current market value of property, member of environmental organization, size of property in acres, number of bedrooms, years of mountain property ownership, year mountain home built, willingness to pay to live in a mountain home, total monthly housing cost, consumer surplus benefit of mountain home living, annual days of outdoor recreation, annual days of vacation, years of education, employment as a worker, for the government, as a professional or manager, retired;

Table 17. Ordinary Least Square Equation Estimates of the Value of Trees to Mountain Homeowners with Five Percent Specimen Trees 24 Inches dbh or More, Front Range, Colorado, 1980.

Independent Variables	Regression Coefficients[a] Unimproved
Importance of Trees in Far View, 5-point scale	-35.5212 (-3.34)
Worth More than Cost to Live in Mountain Home, 1=yes; 2=no	-59.0930 (-2.60)
Sex, 1=male; 2=female	-44.2804 (-2.31)
Member of Sportsman Organization, 1=yes; 2=no	-36.2554 (-1.78)
Constant	374.4458 (6.8243)
Adjusted R^2	.22
F Significance	6.90
Number of Observations	64

a. Numbers in parentheses below each coefficient represent student t-ratios for the null hypothesis. All variables are significant at the .00 to .10 confidence levels.

preference for trees relative to topography, rock outcroppings, view of the mountains, and nearness to streams and lakes; and preference for trees on mountain property an adjacent property, and in the near view.

Other important variables were controlled independent of the regression analysis. The willingness to pay questions assumed that the mountain property shown in the color pictures were exactly the same except for the presence of specimen trees. Ponderosa pine trees were in a scattered arrangement. The size of lot was held constant at one acre, roughly 200 x 200 feet. Topography was specified as gently sloping land with little or no rolls. Access was by public road in front of the property. All schools were equally close and lots were in the same subdivision located in the Front Range of Colorado. Available utilities included electricity, sewer and water in front of the lot. The house was valued at $80,000 and included 1,500 to 2,000 square feet of living space, two baths, two-car garage, fireplace, three bedrooms, and a family room. Land value was $10,000-$20,000 for a one-acre tract. Both house and lot values were consistent with values reported in the study area.

Men were more sensitive to the loss of large specimen trees on mountain property than women. The effect of a five percent loss of specimen trees was $4,428 per acre more for men than women.

Individuals who reported receiving consumer surplus benefit from mountain home living were more sensitive to the loss of large specimen trees than those who reported none. The effect of a loss of five percent specimen trees was $5,909 per acre more for those who reported that it was worth more than their cost to live in mountain homes.

As expected, some groups were more sensitive to the loss of five percent specimen trees than others. The effect of a loss of five percent specimen trees

was $3,626 per acre more for members of sportsmen's organizations than other groups.

Tastes and preferences also were associated with sensitivity to the loss of five percent specimen trees. The effect of a loss of five percent specimen trees increased by $3,521 per acre with one unit increase in the preference for trees in the far view, based on a five point scale with one most important and five least.

CHANGE IN SPECIES

Table 18 shows the effect of change in the predominant species of trees on mountain property from ponderosa pine to douglas fir. Ponderosa pine have been killed by mountain pine beetle infestation in Front Range forests of the Rocky Mountains, while douglas fir are subject to stunting by spruce budworm infestation, causing discoloration and defoliation of newly grown needles which seldom kills the trees. Mountain homeowners consider the douglas fir superior to ponderosa pine because of this disease resistance. Value of trees per acre would increase by a reported .02 percent with each one percent increase in the proportion of douglas fir on improved mountain property. The average elasticity of tree values with respect to the proportion of douglas fir on mountain property was calculated as .02 percent in the range of 1-100 percent of 212 trees per acre, with all other variables unchanged.

The effect of species of trees was somewhat more on unimproved mountain property. Value of trees per acre would increase by .04 percent with one percent increase in the proportion of douglas fir on unimproved mountain property, or .02 percentage points more than on improved mountain property. Protection of property values related to forest quality was more important before residences were constructed on lots in mountain subdivisions.

Table 19 shows the significant social and economic variables associated with change in species and the value of trees on improved and unimproved mountain property. Number of observations included in the regression model was 64, which was sufficient for statistically significant analysis. The proportion of the variation in contribution of trees to property values explained by the independent variables included in the equations was .16 and .22 as measured by R^2 adjusted for degrees of freedom. All regression coefficients were significantly different from zero at the 0.01 to 0.10 level. The overall equations

Table 18. Value of Trees to Mountain Homeowners with Change in Species from Ponderosa Pine to Douglas Fir, Front Range, Colorado, 1980.

Change in Species	Value of 212 Trees Per Acre Six Inches dbh or More	
	Improved	Unimproved
With Ponderosa Pine	$15,297 (8,856)[b]	$11,093 (7,436)
With Douglas Fir	$15,594 (9,445)	$11,508 (7,707)
Change in Value	$ 297	$ 415
Percent Change	1.94	3.74
Elasticity[a]	0.02	0.04

a. Average elasticity calculated as percent change in value of trees divided by 100 percent change in species.

b. Standard deviation in parentheses.

Table 19. Ordinary Least Square Equation Estimates of the Value of Trees to Mountain Homeowners with Change in Species from Ponderosa Pine to Douglas Fir, Front Range, Colorado, 1980.

Independent Variables	Regression Coefficients[a]	
	Improved	Unimproved
Years Lived in Mountain Home		-1.7788 (-1.69)
Importance of Trees on Adjoining Property, 5-point scale	-46.6802 (-2.89)	
Year Mountain Home Built		-1.7309 (-3.24)
Annual Days of Outdoor Recreation	.2387 (1.72)	
Sex; 1=male, 2=female	-47.9257 (-1.92)	
Total Monthly Housing Cost		-0.1068 (-3.76)
Worker; 1=yes, 0=no		42.7303 (2.03)
Constant	278.3570 (5.57)	276.2483 (6.40)
Adjusted R^2	.16	.22
F Significance	5.13	5.49
Number of Observations	64	64

a. Number in parentheses below each coefficient represents t-ratios for the null hypothesis. All variables are significant at the .00 to .10 level of confidence.

were statistically significant at the 0.01 level as indicated by an F value of 5.13 and 5.49. The usual tests of the assumptions of the linear regression model revealed no significant effects on the study results.

Ordinary least squares statistical methods were used to estimate the coefficients and the constants of the general equations. Variables which were positively associated with change in species and the value of trees include: annual days of outdoor recreation, employment as worker, sex male, and the preference for trees on adjoining property. Variables which were negatively associated with change in species and value of trees include: years lived in mountain home, year mountain home built, and total monthly housing cost. Other social and economic variables which were tried and found not significantly associated with the effect of species on tree values include: total willingness to pay to live in a mountain home, consumer surplus benefit of mountain home living, years lived in the study area, years of mountain property ownership, worth more than cost to live in mountain home, number of bedrooms, size of property in acres, annual days of vacation, annual household income, family size, age, sex, years lived in mountain home, housewife, government employee, professional or manager, retired member of sportsman's or environmental organizations, importance of trees relative to topography, rock outcroppings, view of the mountains, and nearness to streams and lakes; and importance of trees on the property and in the far view.

Other important variables were controlled independent of the regression analysis. The willingness to pay questions assumed that the mountain property shown in the color pictures were exactly the same except for the number of trees. The size of lot was held constant at one acre, roughly 200 x 200 feet.

Ponderosa pine trees were in a scattered arrangment. Topography was specified as gently sloping land with little or no rolls. Access was by public road in front of the property. All schools were close and lots were in the same subdivision in the study areas in Front Range forests. Utilities included electricity, sewer and water were available in front of the lot. The house was valued at $80,000 and included 1,500 to 2,000 feet of living space, two baths, two-car garage, fireplace, three bedrooms, and a family room. Lot value averaged $10,000-$20,000 consistent with values reported in the study areas.

Leisure time to engage in outdoor recreation contributed to knowledge of forest conditions and sensitivity to species of trees on mountain property. As expected, the effect of species on the value of trees on improved property increased by $23 per acre with each additional day of outdoor recreation per year.

Men were more sensitive to the effect of change in species of trees on improved mountain property values than women. The effect of changes in species on tree value was $4,793 per acre more for men than women. Many construction workers have built their own homes in the Front Range of Colorado, which contributes to sensitivity to species of trees on neighboring unimproved mountain property. Workers valued trees on unimproved property by nearly $4,273 per acre more than other mountain homeowners. Individuals whose total monthly housing cost was less than average were more sensitive to the effect of change in species of trees on unimproved mountain property values than those with higher cost. The effect of changes in species on tree values increased by nearly $107 with each $10 decrease in monthly housing cost. Individuals living in Front Range mountain homes built in recent years were more sensitive to species of trees than those living in older homes. The effect of change in species on unimproved property

values increased by $173 per acre with one year decrease in number of years since construction of mountain homes. This was consistent with the finding that years of mountain home living was negatively associated with the value of change in species. The effect of species on improved mountain property values decreased by $178 per acre with each additional year of mountain home living. Those who moved to Front Range mountain property in recent years were more sensitive to species of trees than those who have lived there for many years.

As expected, some groups were more sensitive to the effect of change in species of trees on improved mountain property values than others. The effect of change in species on tree values was $4,168 per acre more for members of sportsman's organizations than other groups.

Tastes and preferences also were associated with sensitivity to species of trees on Front Range mountain property. The effect of species on the value of trees on improved property increased by $4,668 per acre with one unit increase in the preference for trees on adjacent property, based on a five-point scale with one most important and five least.

DISTRIBUTION OF TREES

Table 20 shows the effect of a mountain pine beetle attack killing all of the trees on part of mountain property. Value of trees per acre would decrease by a reported -0.29 percent with a one percent increase in non-forested clearing resulting from mountain pine beetle infestation of improved mountain property. The average elasticity of tree values with respect to distribution of trees was calculated as -0.29 percent in the range of 1-50 percent concentration of trees on one-half of one-acre tracts, all other variables unchanged.

The effect of distribution of trees would be more than twice as great on unimproved mountain property. Value of trees per acre would decrease by -0.40 percent with one percent increase in non-forested clearing on unimproved tracts, or 0.11 percentage points more than for improved mountain property. Prospective buyers of unimproved lots may avoid those with evidence that up to one-half of the area has been clear-cut, even though the same number of trees per acre remain in a concentrated area. For owners of improved mountain property, clear-cut of up to one-half of their tracts may open up a vista and provide pasture for horses, while the same number of trees per acre remain in a concentrated area.

Table 21 shows the significant social and economic variables associated with the value of trees when distributed on 50 percent of improved and unimproved mountain property. Number of observations included in the regressional model was 64, which was sufficient for statistically significant analysis. The proportion of the variation in contribution of trees to property values explained by the independent variables included in the equations was .19 and .23 as measured by R^2 adjusted for degrees of freedom. All regression coefficients were significantly different from zero at the 0.01 to 0.10 level. The overall

Table 20. Value of Trees to Mountain Homeowners with Change in the Distribution of Trees, Front Range, Colorado, 1980.

With and Without Change in Distribution	Value of 212 Trees Per Acre Six Inches dbh or More	
	Improved	Unimproved
Without Concentration of Trees	$15,297 (8,856)[b]	$11,093 (7,436)
With Trees Concentrated on 50 Percent of Site	$13,055 (8,568)	$ 8,875 (6,315)
Change in Value	-$ 2,242	-$ 2,218
Percent Change	-14.66	-19.99
Elasticity[a]	- 0.29	- 0.40

a. Average elasticity calculated as percent change in value of trees divided by 50 percent change in random distribution of trees on a one acre tract.

b. Standard deviation in parentheses.

Table 21. Ordinary Least Square Equation Estimates of the Value of Trees to Mountain Homeowners with Change in the Distribution of Trees, Front Range, Colorado, 1980.

Independent Variables	Regression Coefficients[a]	
	Improved	Unimproved
Importance of Trees on Adjoining Property, 5-point scale	-34.4570 (-2.4)	
Importance of Trees in Far View, 5-point scale		-16.0632 (-1.79)
Importance of Trees Relative to Topography 5-point scale		-33.3754 (-3.35)
Number of Bedrooms in Mountain Home		-20.6156 (-2.05)
Annual Days of Vacation	0.2408 (1.68)	
Annual Days of Outdoor Recreation	.4111 (3.22)	
Member of Sportsman Organization, 1=yes; 2=no	-38.6117 (-1.69)	
Worker, 1=yes;		33.7277 (1.83)
Constant	140.2689 (4.29)	253.1027 (5.32)
Adjusted R^2	.19	.23
F Significance	5.89	5.59
Number of Observations	64	64

a. Numbers in parentheses below each coefficient represent student t-ratios for the null hypothesis. All variables are significant at the .00 to .10 confidence levels.

equations were statistically significant at the 0.01 level as indicated by an F value of 5.29 and 5.89. The usual tests of the assumptions of the linear regression model revealed no significant effects on the study results.

Ordinary least squares statistical methods were used to estimate the coefficients and the constants of the general equations. Variables which were positively associated with the value of trees when distributed on 50 percent of mountain property include: annual days of outdoor recreation, member of sportsman's organization, employment as worker; and importance of trees relative to topography, on adjoining property and in the far view. Variables which were negatively associated with the value of trees when distribution on 50 percent of mountain property include: annual days of vacation and number of bedrooms in mountain homes. Other social and economic variables which were tried and found not significantly associated with the effect of distribution of trees on values include: total willingness to pay to live in a mountain home, total monthly housing cost, worth more than cost to live in mountain home, consumer surplus benefit of mountain home living, annual household income, age, sex, years lived in mountain home, years lived in the study area, years of mountain property ownership, number of bedrooms, size of property in acres, housewife, government employee, professional or manager, retired, member of environmental organization; importance of trees relative to rock outcroppings, view of the mountains, and nearness to streams and lakes; and importance of trees on the property.

Other important variables were controlled independent of the regression analysis. The market value questions assumed that the mountain property shown in the color pictures were exactly the same except for the number of trees.

Ponderosa pine trees were in a scattered arrangement. The size of lot was held constant at one acre, roughly 200 x 200 feet. Topography was specified as gently sloping land with little or no rolls. Access was by public road in front of the property. All schools were equally close and lots were in the same subdivision in the Front Range of Colorado. Available utilities included electricity, sewer and water in front of the lot. The house was valued at $80,000 and included 1,500 to 2,000 square feet of living space, two baths, two-car garage, fireplace, three bedrooms, and a family room. Land value was $10,000 to $20,000 for a one-acre tract. Both house and lot values were consistent with values reported in the study area.

Leisure time to engage in outdoor recreation contributed to knowledge of forest conditions and sensitivity to the distribution of trees on mountain property. As expected, the effect of clear cutting trees on improved property increased by nearly $41 per acre with each additional day of outdoor recreation per year. However, annual days of vacation did not contribute to the sensitivity to distribution of trees improved mountain property. The effect of clear cutting trees increased by $24 per acre with one day decrease in annual vacation. This reflects the fact that vacations are usually spent away from home traveling outside of Front Range forests.

Many construction workers have built their own homes in the Front Range of Colorado, which contributes to sensitivity to the distribution of trees on neighboring unimproved mountain property. The effect of clear cutting unimproved property was nearly $3,373 per acre more for workers than other mountain homeowners. The value of clear cutting on unimproved mountain property cannot be attributed to the size of houses. The value of trees decreased by $2,062 per

acre with each additional bedroom in mountain homes. Thus, those with smaller mountain homes were more sensitive to clear cutting of trees than those with larger homes.

As expected, some groups were more sensitive to the effect of distribution of trees on tree values than others. The effect of clear cutting was $3,861 per acre more for members of sportsman's organizations than other groups.

Tastes and preferences for trees also were associated with sensitivity to the distribution of trees on Front Range mountain property. The effect of clear cutting trees on improved property increased by $3,446 per acre with one unit increase in the importance of trees on adjoining mountain property, based on a five-point scale with one most important and five least. This compares to an increase of $1,606 per acre with a one unit increase in the importance of trees in the far view from unimproved property, and an increase of $3,338 per acre with a one unit increase in the preference for trees relative to topography.

REGROWTH OF INSECT DAMAGED FOREST

Table 22 shows the effect of the regrowth of an insect damaged forest on the contribution of trees to the value of improved and unimproved mountain property. Results of the homeowner survey were utilized to estimate the effects of change in the size of ponderosa pine trees as future regrowth occurs on mountain property after mountain pine beetle infestation. Such information could improve the accuracy of converting the reported present value to annual value of trees on Front Range mountain property with and without mountain pine beetle control.

It should be noted that Table 22 assumes no recovery of the damages to forest values during the first twenty years after mountain pine beetle kills trees on mountain property. This is based on the belief that there would be little or no recovery of property values from the loss of trees until replacement trees reach five feet in height, equivalent to approximately one inch dbh. This would depend on growth conditions at the affected forest sites. If seedlings and small trees were present in the undercover at the time of attack, pine beetle kill of large trees may regrow to one inch dbh in five-ten years. The same may be true in the case of replanting forests after a beetle attack. However, on many north facing dry slopes of the Front Range, natural reseeding of ponderosa pine may occur very slowly if at all. Meyer [1966] estimated that ponderosa pine tree regrowth would reach 1.2 to 1.7 inches dbh in twenty years, with conditions similar to the Front Range of Colorado, i.e., site index of 40-50.

The results of this study indicate that approximately twenty years after an initial mountain pine beetle attack, lost trees usually will be replaced by new

Table 22. Effect of Regrowth of an Insect Damaged Forest on the Value of Trees to Mountain Homeowners, Improved and Unimproved One Acre Tracts, Front Range, Colorado, 1980 to 2080.

Year	Tree Diameter, Inches dbh[a]	Improved		Unimproved	
		Value of Trees	Index of Recovery	Value of Trees	Index of Recovery
0	0	$ 0	0	$ 0	0
5	0	0	0	0	0
10	0	0	0	0	0
15	0	0	0	0	0
20	1.70	10,876	.75	8,892	.80
25	2.63	11,839	.81	9,483	.85
30	3.55	12,571	.86	9,942	.89
35	4.47	13,172	.91	10,324	.93
40	5.40	13,684	.94	10,653	.96
45	6.32	14,135	.97	10,945	.98
50	7.25	14,506	.99	11,189	1.00
55	7.85	14,782	1.02	11,370	1.02
60	8.53	15,039	1.03	11,540	1.04
65	9.21	15,282	1.05	11,701	1.05
70	9.84	15,511	1.07	11,854	1.06
75	10.57	15,729	1.08	12,000	1.08
80	11.25	15,937	1.10	12,139	1.09
85	11.94	16,135	1.11	12,272	1.10
90	12.62	16,325	1.12	12,401	1.11
95	13.30	16,507	1.14	12,524	1.12
100	13.98	16,682	1.15	12,644	1.13

a. Growth of managed ponderosa pine stands with a ten-year cutting cycle and site index of 50 [Myers, 1966; 14].

growth averaging 1.7 inches dbh. With such small trees, the contribution of trees to improved mountain property values would equal $10,876 per acre, compared to $8,892 per acre of unimproved mountain property. This represents a 75 percent recovery of the initial value of trees on improved mountain property before the mountain pine beetle infestation occurred, and an 80 percent recovery of the initial value of trees on unimproved mountain property.

With subsequent increases in the size of replacement trees, the contribution of trees to the value of improved mountain property would increase. For example, 35 years after an initial mountain pine beetle attack, the contribution of trees to the value of improved mountain property would increase to $13,172 per acre, compared $10,324 per acre of unimproved mountain property. This represents a 91 percent recovery of the initial value of trees on improved mountain property before the mountain pine beetle infestation occurred, and 93 percent recovery of the initial value of trees on unimproved mountain property.

Full recovery of the contribution of trees to mountain property values would occur approximately 50-55 years after an initial mountain pine beetle attack when it is estimated that regrowth of an insect damaged ponderosa pine forest would reach 7-8 inches dbh. This may be somewhat low as the approximately average size of mountain pine beetle killed trees in Colorado has been 10 inches dbh [McCambridge, Hawksworth, and Laut, 1981]. With full recovery of forest quality, the contribution of trees to improved mountain property values would equal $14,600 per acre, compared to $11,200 per acre of unimproved mountain property.

For purposes of benefit cost analysis, it can be assumed that no damages to Front Range mountain property would be incurred beyond a growth cycle of

50-55 years. It is interesting to note, however, that the contribution of trees to mountain property values would continue to increase with tree growth beyond 50-55 years at least to 100 years with average tree size of 14 inches dbh. The results presented in an earlier section of this report suggest that tree values would continue to increase with forest growth to 24 inches dbh. The beneficial effect of forest growth on mountain property values from 8-24 inches dbh would be lost for 55 years after an initial mountain pine beetle attack. It would be strictly correct to include these damages in the benefit cost calculation. They could be estimated on the basis of the following equations:

Contribution of trees to improved property values,	<50 years	$= 75.2187(-1.99 + .1847YEAR)^{.2457} + 23.02$
	≥50 years	$= 75.2187(.3598 + .1362YEAR)^{.2457} + 23.02$
Contribution of trees to unimproved property values,	<50 years	$= 36.2667(-1.99 + .1847YEAR)^{.3003} + 46.36$
	≥50 years	$= 37.2667(.3594 + .1362YEAR)^{.3003} + 46.36$

Where the contribution of trees to property values (in $100s) is the dependent variable, and YEAR equals the year in the regrowth cycle forced through the mean of tree values.

Mountain property is owned because it provides a stream of productive services. The present value of forest quality is defined in terms of changes in the annual value of these services. However, in this study it was the present value of the contribution of trees to the market value of mountain property which was reported by homeowners, and inferences about the stream of annual values requires converting the reported present value to annual values. Including the effect of regrowth of an insect damaged forest has a substantial effect on accuracy of the conversion of the reported present values to annual values. For example, the present value of $1 loss of improved mountain property values annually

over 50 years growth cycle of ponderosa pine would be $18.45 without including regrowth of an insect damaged forest in the calculation, and $12.72 with regrowth of the damaged forest included in the calculation. By comparison, the present value of $1 loss of unimproved mountain property values annually over 50 years growth cycle of ponderosa pine would total $22.49 without including regrowth, compared to $14.19 with regrowth effects included. Thus, including regrowth effects in the calculation reduces the present value estimate by 31.1 to 36.9 percent per $1 of annual value. Both of these comparisons assume that development of residences in mountain subdivision would continue to grow at an annual rate of 4.8 percent and the plotting of unimproved lots at an annual rate of 6.0 percent, the compound annual growth rates estimated for 1970-1980 on the Front Range of Colorado. Present value was calculated for a 50 year planning period with a 10 percent discount rate.

A 10 percent discount rate is based on an opportunity cost of capital averaging 12 percent, a marginal income tax rate of 30 percent, and property tax rate of 2 percent on owner occupied mountain homes [Freeman, 1980]. Moreover, a 10 percent discount rate conforms with the U.S. Office of Management and Budget guideline requiring present value of benefit and cost of government programs be calculated using 10.0 percent and at a lower agency approved rate of discount. The U.S. Forest Service currently uses a 4.0 percent discount rate. To convert the 10.0 percent rate to 4.0 percent, multiply by approximately 2.17.

APPLICATION TO CONTROL DECISIONS

Table 23 shows the economic efficient level of annual expenditure on mountain pine beetle control by owners of improved and unimproved mountain property. If owners incur no costs of forest management such as insect control, the optimum number of trees on mountain property would be where total present value to owners is maximized and marginal value is zero. For mountain homeowners in Front Range forests, this would exceed 300 trees per acre six inches dbh or more. With the introduction of costs of forest management such as to prevent insect infestation, the optimum number of trees to protect would fall. The optimum number of trees per acre, on grounds of economic efficiency, would occur where marginal benefit equals marginal cost per tree.

Table 23 shows that with marginal cost of forest management including insect control equaling about $3 per tree annually, the optimum number of trees to protect on improved mountain property would be 150-175 trees per acre. This would be equivalent to an insect control program which sprayed every two years at marginal cost of $6 per tree or a thinning program to encourage vigorous growth every five years at a marginal cost of approximately $15 per tree.

With the protection of 150-175 trees per acre, average annual owner benefit would equal $8 per tree. In the case of the purchase of commercial insect control services, marginal cost would equal the average price paid. Thus, the annual benefit cost ratio of an owner's insect control program would be calculated as $8/$3 = 2.6. This means that for a $1 expenditure on forest insect control, owners would receive benefit of $2.60.

It should be noted that the recommended levels of mountain pine beetle control are based on a restricted case, average individual homeowner value of trees

Table 23. Sensitivity of the Economic Efficient Level of Owner Annual Expenditure on Mountain Pine Beetle Control to Number of Trees Six Inches dbh or More per Acre on Improved and Unimproved Mountain Property, Front Range, Colorado, 1980.

Number of Trees Per Acre Six Inches dbh or More	Efficient Level of Annual Expenditure Per Tree (Marginal Benefit = Marginal Cost)		Average Annual Benefit Per Tree		Benefit Cost Ratio of Control Program	
	Improved	Unimproved	Improved	Unimproved	Improved	Unimproved
10	$6.38	$4.31	$58.26	$47.69	9.1	11.1
25	6.05	4.07	27.03	21.59	4.5	5.3
50	5.50	3.67	16.40	12.73	3.0	3.5
75	4.95	3.27	12.67	9.65	2.6	2.9
100	4.40	2.87	10.67	8.00	2.4	2.8
125	3.85	2.47	9.36	6.94	2.4	2.8
150	3.30	2.07	8.40	6.16	2.5	3.0
175	2.75	1.67	7.63	5.55	2.8	3.3
200	2.20	1.27	6.98	5.04	3.2	4.0
225	1.65	0.87	6.42	4.60	3.9	5.3
250	1.10	0.47	5.92	4.21	5.4	8.9
275	0.55	0.07	5.45	3.85	9.9	
300	0.00	--	5.02	3.32		

a. Reported present values of trees were converted to annual values based on a perpetual benefit stream with sustained yield forest practices, where annual value equals present value times the rate of discount. A 10 percent discount rate was based on an opportunity cost of capital averaging 12 percent, a marginal income tax rate of 30 percent, and property tax rate of 2 percent on owner occupied mountain homes [Freeman, 1980].

contingent on changes in the number of live trees six inches or more on their own private property. Omitted from these calculations are other private values such as resulting from discoloration of needles during the second year after an initial mountain pine beetle attack and for the duration of a spruce budworm outbreak, dead and down trees during approximately the 2-10 years after initial insect attack, loss of specimen trees, and other private values. Also omitted are the external values associated with trees on adjoining property viewed from an individual homeowner's property, and the effect of projection of tree values with continued development of mountain subdivisions over the next 50 years, and recovery of tree values with regrowth of an insect damaged forest. The economic efficient level of expenditure on forest insect control by an association of homeowners and/or a public agency would be more than an individual owner.

Table 23 summarizes the effect of insect infestation on the aggregate present value of trees to property owners in the Front Range of the Colorado Rocky Mountains. The average values reported by the sample of homeowners was expanded to the population of 62,000 improved properties and 112,000 unimproved properties in 1980. Implicit in this expansion is the conservative assumption that improved and unimproved mountain property averages one acre in size. Also, it should be noted that future development of mountain subdivisions would increase the effect of insect infestation shown here.

The largest effect on tree values was from visible forest insect damage. Needles turn rust color from mountain pine beetle infestation of ponderosa pine while new growth is discolored and defoliated by spruce budworm infestation of douglas fir. With 15 percent of the trees showing discolored on defoliated needles, present value of trees on improved property would decrease by $323.6

million, compared to $335.8 million on unimproved property. This would occur during the second year after the initial mountain pine beetle attack of ponderosa pine trees, and presumably would not re-occur once the needles fall from dead trees by the third year. It is possible that this would occur throughout the period of time in which spruce budworm defoliate douglas fir trees continuing for many years. However, respondents were not specifically asked to report the effect of spruce budworm defoliation, just the effect of 15 percent visible insect damage.

The second largest effect on trees values was reported when forest entomologists predict a general outbreak of forest insect infestation which would kill 15 percent of the trees on mountain property within five years. With the expectation that 15 percent of the trees would be killed, present value of trees on improved property would decrease by $108.1 million, compared to $113.2 million on unimproved property. This would occur during the period of initial outbreak and continue until either damage to trees on the property occurred or the outbreak ended.

The long-run effects of forest insect infestation would be: changes in the number of trees on mountain property, on adjacent property in the near view, distribution of live trees on the property, average size of surviving trees, and loss of large specimen trees. With 15 percent fewer trees on improved mountain property the present value of trees would decrease by an estimated $45.3 million, compared to $48.0 million on unimproved property. With 15 percent fewer trees on adjacent property in the near view, the present value of trees to owners of improved property would decrease by $27.7 million.

If as is often the case, forest insects attack 15 percent of the trees in a concentrated area on part of the property, the present value of trees on improved mountain property would decrease by an estimated $41.7 million, compared

Table 24. Summary of the Effect of Insect Infestation on the Value of Trees on Improved and Unimproved Mountain Property, Front Range, Colorado, 1980.

Forest Quality Effect	Duration of Effect	Effect of One Percent Insect Infestation		Effect of 15 Percent Insect Infestation		Aggregate Present Value of 15 Percent Insect Infestation in Front Range Forests ($1,000s)
		Percent	Present Value per Acre	Percent	Present Value per Acre	
Number of Live Trees Six Inches dbh or More on Mountain Property	10-19 yrs, constant 20-50 yrs, declining					
Improved		0.34	$ 48.67	5.14	$ 730	$ 45,260
Unimproved		0.28	28.60	4.20	429	47,997
Number of Live Trees Six Inches dbh or More on Adjacent Property	10-19 yrs, constant 20-50 yrs, declining					
Improved		0.20	29.80	2.98	447	27,714
Size of Trees	10-19 yrs, constant 20-50 yrs, declining					
Improved		0.35	60.72	5.25	911	56,482
Unimproved		0.33	38.75	4.95	581	65,003
Expectation of 15 Percent Insect Kill	Continuous during outbreak					
Improved		0.76	116.26	11.40	1,744	108,128
Unimproved		0.61	67.48	9.15	1,012	113,225
Visible Forest Insect Damage on Mountain Property	Second Year After Initial Mountain Pine Beetle Attack; Continuous during Spruce Budworm Defoliation					
Improved		2.27	347.87	34.11	5,218	323,516
Unimproved		1.80	200.07	27.05	3,001	335,758
Distribution of Live Trees on 85 Percent of Property	10-19 yrs, constant 20-50 yrs, declining					
Improved		0.29	44.84	4.35	673	41,726
Unimproved		0.40	44.36	6.00	665	74,402
Change in Species, from Ponderosa to Douglas Fir, 15 percent						
Improved		0.02	2.97	0.30	45	2,790
Unimproved		0.04	4.15	0.60	62	6,937
Specimen Trees, 5 Percent	1-19 yrs, constant 20-180 yrs, declining					
Improved		3.64	680.60			
Unimproved		2.61	333.00			

to $74.4 million on unimproved property. This would be the effect on tree values from clear-cutting 15 percent of mountain property. With 15 percent reduction in the average size of surviving trees, the present value of trees to owners of improved property would decrease by $56.5 million, compared to $101.1 million on unimproved property. However, this effect would not be constant over the 50 year tree growth cycle. It would decline as replacement trees grew from 1-7 inches dbh from approximately 20-50 years after the initial forest insect infestation. In addition, there would be a substantial loss in the value of trees to mountain property owners when a few large specimen trees are killed by insect infestation. However, it was not possible to provide an estimate of the effect of the loss of large specimen trees for the Front Range because the number of such magnificant trees lost has not been estimated.

CONCLUSIONS

The purpose of this study was to develop and apply a procedure for measuring the contribution of trees to the economic value of improved and unimproved mountain property. The results of the study provide an empirical basis for estimating the benefits to mountain property owners from mountain pine beetle and spruce budworm infestation control programs, both private and public. Mountain property owners reported maximum willingness to pay for trees contingent on changes in several important forest quality variables including: number of trees six inches dbh on mountain property and in the near view on adjacent property; size of trees, presence of large specimen trees, expectation of insect damage, visible insect infestation, change in species, and distribution of trees on the property. Without such information, insufficient resources would be allocated by property owners and society to protection of forest quality.

In addition to the contribution of trees to private property values reported here, the general public may value the preservation of forest quality and be willing to pay for: the option to have access to or purchase property with outstanding forest resources in the future; the knowledge that forest quality exists and is protected; and the satisfaction from the bequest of forest quality to future generations. Moreover, the willingness to pay reported by mountain property owners here was constrained by limited household income and other variables [Gordon and Knetsch, 1979]. There may be psychological values associated with forest quality which exceed the contribution of trees to property values reported here [Driver and Brown, 1975].

In addition to the contribution of trees to mountain property values, there may be long-run ecological values which are not included here. It is difficult

for biologists to predict what these might be let alone measure and incorporate them into a property value estimate. For this reason it seems that the present economic value of trees on mountain property represents a conservative estimate of the total value to society of protecting forest quality. The inability of economic analysis to place a dollar value on unknown ecological effects should be recognized in making decisions about mountain pine beetle and spruce budworm infestation control programs.

APPENDIX

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Interview Number _____
Interviewer _____
Date _____ Time _____
Location _____

MOUNTAIN HOMEOWNERS AND FOREST QUALITY

Good morning/afternoon. My name is _____. I work for Colorado State University in Fort Collins. We are studying the effect of trees on the market value of mountain property. In the past, forest insects such as the mountain pine beetle and spruce budworm have reduced the number of trees on residential property in the Front Range of Colorado. Beetle kill and budworm defoliation are likely to occur in the future. Would you mind if I ask you a few questions? It will probably take about 10 to 15 minutes. You are under no obligation to participate, but the opinions of those who do may contribute to decisions about managing forests in Colorado. You personally will not be identified in reporting the results of the study.

1. For how many years have you owned this property? _____years. How many years have you lived in mountain areas? _____years.

   Homeowners will then be shown 6 pictures of unimproved mountain real estate with varying numbers of trees 6 inches in diameter breast height (dbh) or greater.

2. In your opinion, do trees affect the market value of mountain real estate? Yes ___ No ___ Comments _____

3. How important are trees to you as an owner of mountain real estate? Answer 4 parts.

	Extremely Important	Very Important	Moderately Important	Somewhat Important	Not Important
a. Trees on property purchased?	___	___	___	___	___
b. Trees on adjoining property (the near view)?	___	___	___	___	___
c. Trees in the far mountain view?	___	___	___	___	___

   d. Comments: _____

4. How important are trees to you as an owner of mountain real estate relative to other characteristics of your site?

	Much More	More	Same	Less	Much Less
a. Rock outcroppings	___	___	___	___	___
b. Nearness to streams and lakes	___	___	___	___	___
c. Topography	___	___	___	___	___
d. Rocky mountain view	___	___	___	___	___
e. Other (specify) _____	___	___	___	___	___
f. Other (specify) _____	___	___	___	___	___

PLEASE KEEP IN MIND THAT THE NEXT SEVERAL QUESTIONS ARE A HYPOTHETICAL EXPERIMENT INTENDED TO PROVIDE SOME NOTION OF HOW YOU VALUE THE NUMBER OF TREES ON IMPROVED AND UNIMPROVED MOUNTAIN PROPERTY

Assume that the properties shown in the pictures are exactly the same except for number of trees per acre.

Characteristics common to all sites:

Size of lot:	Roughly one acre (40,000 sq. ft. 200 x 200 feet)	Location:	All lots in the same subdivision in the vicinity of _____, Colorado
Topography:	Gently sloping land, little or no rolls	Tree Species:	Ponderosa Pine in a scattered arrangement
Utilities:	Electricity, sewer and water	House:	1,500 to 2,000 square feet of living space, 2 baths, 2-car garage, fireplace, 3 bedrooms, family room
Access:	Public road in front		
Schools:	All schools equally close		

5. Estimate the contribution of trees to the market value of unimproved one acre lots with forest quality like picture ___ with ___ trees per acre, in relation to the first picture which has a market value of $ _____ and is assumed to be comparable except that it has no trees.* (Repeat question for low, medium, and high tree pictures and record values below. Choose a reasonable lot value of $10,000 or $20,000 for Q5 and Q6.)

Pictures, Number of Trees per Acre, and Estimated Market Value

No trees	Low	Medium	High
	___ trees	___ trees	___ trees
$_____	$_____	$_____	$_____

6. Estimate the contribution of trees to the market value of improved one acre tracts with forest quality like picture ___ with ___ trees per acre, in relation to the first picture which has a market value of $ _____ including a $ _____ lot (Q.5) and an $80,000 house. Assume the properties are exactly the same except for number of trees. (Repeat question for low, medium, and high tree pictures and record values below.)

No trees	Low	Medium	High
	___ trees	___ trees	___ trees
$_____	$_____	$_____	$_____

7. *(Ask if respondent reports that market value is not affected by forest quality:) What is the reason?

a. Property owners are not adversely affected by forest quality?
b. You believe mountain property is already overvalued?
c. You believe it is unfair to expect property owners to pay for forest quality which should be provided by public agencies from tax revenues?
d. Other? (Specify)_____

_____

8. What would be the neighborhood effect of varying levels of forest quality? Assume that the view from the front of the residential tracts would vary as shown in the pictures. Estimate the change in current market value of your highest valued improved tract.

View from Front, Number of Trees Per Acre, and Estimated Market Value

No trees	Low	Medium	High
	___ trees	___ trees	___ trees
$_____	$_____	$_____	$_____

9. a. Aside from forest quality, what other important resources do you notice in the pictures? _____

_____

b. How would you rate the quality of these other resources shown in the pictures? (specify resources)

	Very Good	Good	Fair	Poor	Very Poor
_____	___	___	___	___	___
_____	___	___	___	___	___
_____	___	___	___	___	___

c. Comments _____

_____

10. How would your highest tree values change if conditions changed in the following ways? Answer in terms of change in the total value reported for your highest priced picture.

a. Arrangement of trees on property would change from a scattered pattern to a concentrated grouping on one-half of the lot with one-half open space. Unimproved $_____ Improved $_____

b. Predominant species of trees on property would change from Ponderosa Pine (which are subject to beetle kill) to Douglas Fir (which are attacked by spruce budworm causing defoliation and browning but which seldom kills the tree). Unimproved $_____ Improved $_____

c. Forest entomologists report that one-half of the trees on the lot would be killed by insect infestation within five years. Unimproved $_____ Improved $_____

d. Residential tracts would have the same number of trees but the 6 inch dbh minimum tree size (or diameter) would change to:

1) One-half as large (3 inches dbh). Unimproved $_____ Improved $_____

2) Twice as large (12 inches dbh). Unimproved $_____ Improved $_____

3) Five percent of trees would be magnificent specimens, four times as large (24 inches dbh). Unimproved $_____ Improved $_____

e. Size of lot would change from one acre to one-half acre (while tree density per acre and tree size would not change). Unimproved $_____ Improved $_____

f. Size of lot would change from one acre to two acres (while tree density per acre and tree size would not change). Unimproved $_____ Improved $_____

g. Basic value of the house and neighboring houses would double from $80,000 to $160,000 (plus lot), $_____

h. Basic value of the house and neighboring houses would fall from $80,000 to $40,000 (plus lot), $_____

i. A substantial number (15 percent) of the Ponderosa Pine trees on the lot would have reddish needles because of beetle kill (see photo). Unimproved $_____ Improved $_____

11. a. When did you purchase this mountain property? 19___

b. Purchase price $_____

c. Please estimate the current market value of your mountain property. $_____

d. Number of acres _____

e. Number of bedrooms _____

f. When built (year) _____

12. a. What is your best estimate of the amount spent annually (monthly) on this mountain home for the following items?

Property taxes	$_____	Insurance	$_____	Water-sewages	$_____
Interest	$_____	Telephone	$_____	Garbage	$_____
Principal	$_____	Electricity	$_____	Heating (if other than electricity)	$_____

b. What was the approximate cost of maintenance, repairs and any new construction during the year?

Building exterior	$_____	Roads and driveways	$_____	Tree spraying	$_____
Building interior	$_____	Water supply and sewage	$_____	Tree removal	$_____

c. So, your total monthly costs were approximately $_____

d. How many people in your household shared these costs? _____Total_____Children_____Teens_____Adults

13. a. What is it worth to live in this mountain home? Is it worth more than the $_____ (from Q12.c) actually spent to live in this mountain area? Yes_____ No_____

b. About how much more is living here worth. Assume that living here became more expensive, due perhaps to higher costs of utilities, etc., what is the maximum you would pay to live here? Would you pay $_____ per month to continue living here? Yes _____ No _____ (Interviewer will then bid prices up by random increments if respondent answers "yes" or down if respondent answers "no" and enter the final amount.)

14. How many days of vacation do you have annually? _____ days

15. How many days did you participate in all kinds of outdoor recreation in the past 12 months? _____days

16. What is your age? _____years

17. Sex: Male _____ Female _____

18. a. What kind of work do you do? Yourself_____ Spouse _____

b. Where do you work? City_____ County_____ State_____

c. Do you commute to work from this site? _____Yes _____No

d. If yes, what percent of time? _____Percent

19. Do you belong to: A sportsman's organization? Yes _____ No _____

An environmental organization? Yes _____ No _____

20. What is the highest year of formal schooling you have completed so far?

8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

21. To the best of your knowledge, what was your household income last year (before taxes)

_____ Under $9,999 _____$20,000 to $24,999 _____$40,000 to $49,999

_____ $10,000 to $14,999 _____$25,000 to $29,999 _____$50,000+ Please specify

_____ $15,000 to $19,999 _____$30,000 to $39,999 to nearest $10,000: $_____

22. Do you have any comments about forest quality management which would help make Colorado a better place to own mountain real estate? _____

_____

FOR SEASONAL RESIDENTS ONLY:

1. Please estimate how many trips you made to your mountain home during the past year? _____Trips

2. About how many miles did you travel from your home one way? _____Miles

3. Please estimate how many days you (your household and nonpaying guests) used your mountain home during the past year. _____days

4. How many days did renters (paying guests) occupy your mountain home in your absence? _____days

What was the rental rate for your mountain home? $_____ (Please specify per day, week or month)

5. If you were unable to visit your mountain home how many miles would you travel from your home to your next most preferred recreation area? _____ miles. Where is this area and what is its name? _____

_____

6. Where do you live? City: _____ Estimated city population: _____

County: _____ State: _____